A REVISION

OF THE

COTYLOSAURIA OF NORTH AMERICA

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PREFACE.

This paper is the second of the series upon the vertebrate fauna of the Permian or Permo-Carboniferous beds of North America. The first, "A Revision of the Pelycosauria of North America," appeared as publication No. 55 of the Carnegie Institution of Washington, in 1907. The third, "A Revision of the Amphibia and Pisces of the Permian of North America," will follow shortly.

Much doubt has recently been cast upon the true Permian age of the Red Beds in Texas, where the fauna is most abundantly represented. Evidence has been brought forward to show that these beds and the fauna in them (which is also present in other parts of the continent) must be referred, in part at least, to the Pennsylvanian age. The name Permian has been retained provisionally in the title until more complete evidence has been gathered. It is hoped that a fourth volume of this series may be completed, gathering together the evidence as to the age of this fauna, its relations to its surroundings, and its origin and final distribution over the world.

In this place, I desire to express my thanks to the Carnegie Institution of Washington for its continued support.

To the authorities of the American Museum of Natural History in New York I am greatly indebted for their kindness in permitting me to study the type material there preserved and to publish illustrations and descriptions of their material. Especially am I under obligation to President H. F. Osborn and to Dr. W. D. Matthew for advice and assistance in the work.

Both Dr. S. W. Williston, of the University of Chicago, and Dr. Richard Broom, of Springs, South Africa, have been of great assistance to me in the preparation of the manuscript.

Finally, I must express my thanks to Mr. Erwin Christman, without whose painstaking care in preparing the illustrations, both this and the forthcoming volume would have lost much in value.

E. C. Case.

A REVISION OF THE COTYLOSAURIA OF NORTH AMERICA.

HISTORICAL REVIEW.

The name *Cotylosauria* was first proposed by Cope in 1881 (21) in a description of the skull of *Empedias* (*Empedocles*). He says: "The relations of the quadrate and the zygomatic arches are as in the *Theromorpha* generally," and makes several statements with regard to the palate and the brain case. The name was suggested by the apparent double articulation of the skull with the vertebral column: "The character of this articulation is so distinct from anything yet known among vertebrated animals that I feel justified in proposing a new division for the *Theromorpha* to include the *Diadectidæ*, to be called the *Cotylosauria*." He evidently intended this group to have rank as a suborder in the order *Theromorpha*.

In June of the same year he published his "Second Contribution to the History of the Permian Formation of Texas" in the "Proceedings of the American Philosophical Society" (22); this also appeared separately as Paleontological Bulletin, No. 32. In these papers the *Cotylosauria* is still reckoned as a suborder of the *Theromorpha*.

In a "Catalogue of the Vertebrata of the Permian Formation of the United States," published in the "American Naturalist" for 1881 (23), the *Diadectidæ* is again considered as a family of the suborder *Pelycosauria*, of the order *Theromorpha* and the name *Cotylosauria* is dropped.

In 1882 (25) Cope was still doubtful about the suborder *Cotylosauria*:

"I am still inclined to question whether the extraordinary characters of the cranio-vertebral articulation I have described justify the separation of the *Diadectidæ* as a third suborder of the *Theromorpha* which I have called the *Cotylosauria*, or whether they are due to the loss of a loosely articulated basioccipital bone."

In no one of three papers published in 1885 (27, 28, 29) and indeed, not again until 1889, does Cope make mention of the *Cotylosauria* in his classificatory lists.

In 1888 Seeley (57) proposed as a classification of the primitive reptiles the following:

Subclass: *Anomodontia.*
Suborder: *Pareiasauria.*
Dicynodontia.
Gennetotheria.
Pelycosauria.
Theriodontia.
Cotylosauria.
Placodontia.

In 1889 Seeley's full paper, of which the above is an extract, appeared in the "Transactions of the Royal Philosophical Society" (58). He defines the suborder *Pareiasauria* as having "Basioccipital articulation. No temporal vacuities. No median bar to interclavicle." The suborder *Cotylosauria* he defined as having "Exoccipital condyles. Molar teeth transversely developed."

In October 1889 Cope presented in the "American Naturalist" (**33**) a "Synopsis of the Families of the Vertebrata," in which the *Cotylosauria* is again mentioned as a suborder of the *Theromorpha* with the families *Pareiasauridæ*, *Pariotichidæ*, and *Diadectidæ*. He defined the *Cotylosauria* as follows: "Ribs single-headed; temporal fossa overroofed; dentition abundant." In this paper Cope considered that he corrected the original erroneous definition of the *Cotylosauria* based on the loss of the basioccipital bone and placed it upon a firm basis.

In the portion of Zittel's "Handbuch der Paleontologie" which appeared the same year (**69**) the *Cotylosauria* is not reckoned as distinct, but the families *Pariotichidæ* and *Diadectidæ* are placed in the suborder *Theriodontia* (*Pelycosauria* Cope) of the order *Theromorpha*.

Lydekker in his "Catalogue of the Fossil Reptilia and Amphibia" in the British Museum, 1890 (**49**), places the member of Cope's *Cotylosauria* in the *Theromorous Branch*, Order *Anomodontia*, Suborder *Theriodontia* with the families *Bolosauridæ* and *Diadectidæ*.

In 1891 (**34**) Cope gave the following arrangement:

Order *Theromora.*
Suborder *Placodontia.*
Family *Placodontidæ.*
Suborder *Proganosauria.*
Families *Mesosauridæ*, *Procolophonidæ*, *Proterosauridæ*, *Rhyncosauridæ.*
Suborder *Anomodonta.*
Families *Dicynodontidæ*, perhaps *Endothiodontidæ.*
Suborder *Theriodontia.*
Families *Clepsydropidæ*, *Pariotichidæ*, *Bolosauridæ.*
Suborder *Cotylosauria.*
Families *Pareiasauridæ*, *Bolosauridæ.*

In 1892 Cope again raised the group to ordinal rank (**35**):

Order *Cotylosauria.*
Genera *Pantylus*, *Chilonyx*, *Pariotichus.*
Branch *Theromora.*
Order *Theriodontia.*
Order *Anomodontia.*

In this paper *Cotylosauria* was considered as the ancestral group of all reptiles.

In the same year Seeley (**59**) placed the group as a suborder of the order *Theriodontia* with the *Gennetotheria* and "probably *Pelycosauria.*"

In 1894 (**36**) Cope gave the classification below:

Order *Cotylosauria* (*Pareiasauria*).
Order *Theromora.*
Suborder *Placodontia.*
Procolophonia.
Anomodontia.
Order *Pelycosauria* (?*Theriodontia*).

In the same year (**37**), in a discussion of Seeley's papers, the order *Cotylosauria* is defended by Cope against Seeley's *Pareiasauria*. He says: "Seeley founded the *Pareiasauria* because the definition of *Cotylosauria* was defective in one respect. This was remedied in 1889" (**33**).

In 1895 Seeley (**60**) proposed his two new orders the *Therosuchia* and *Therochelonia*.

Anomodontia.
Order *Therosuchia.*
Suborder *Pareiasauria.*
Gorgonopsia.
Dinocephalia.
Deuterosauria.
Placodontia.
Theriodontia.
Lycosauria.
Cynodontia.
Gomphodontia.
Endothiodontia.
(*Theromora.*)
Pelycosauria.
Cotylosauria.
Order *Therochelonia.*
Suborder *Dicynodontia.*
Kistecephalia.
Proganosauria or *Mesosauria.*
Nothosauria.
Protorosauria.

In 1895 appeared Bernard's "Paléontologie" (**3**) giving the following classification:

"1er Ordre
Theromorphes (Anomodontes sens. lat.)
1er Sous-ordre Cotylosauriens (Paréiasauriens)
2e Sous-ordre Procolophoniens
3e Sous-ordre Theriodontes
4e Sous-ordre Dicynodontes (Anomodontes s. str.)"

In Zittel's "Grundzüge der Paleontologie" (**70**) the *Cotylosauria* is regarded as a synonym of Seeley's *Pareiasauria* with the families *Pariotichidæ*, *Diadectidæ*, and *Deuterosauridæ*.

In 1896 (**38, 39**) appeared Cope's paper "On the Reptilian Order *Cotylosauria*." He gives the following classification:

Order *Cotylosauria.*
Family *Elginidæ.*
Pareiasauridæ.
Diadectidæ.
Pariotichidæ.

The *Cotylosauria* is defined as follows:

"Quadrate bone united by suture with the adjacent elements. Temporal fossa overroofed by the following elements: Postfrontal, postorbital, jugal, supramastoid, supratemporal, quadratojugal. Tabular bone present. Vertebræ amphicœlous; ribs one-headed. Episternum present. Pelvis without obturator foramen."

Later in the same year came Cope's second paper, "Second Contribution to the Order *Cotylosauria*" (**41**), in which the family *Otocælidæ* was added. A third

paper on the same subject in the same year (40) adds certain facts, but proposes no change in the classification.

In 1896 also appeared the "Primary Factors of Organic Evolution" (42), in which Cope again located the *Cotylosauria* as the most primitive group of the reptilia.

In "Science" for May 7, 1896, Baur (2) published a discussion of *Sclerosaurus armatus* H. v. Meyer, from the Triassic of Germany. He used the caption *Pareiasauria* Seeley (*Cotylosauria* Cope). In private conversation with the author he asserted that because Cope gave up the order *Cotylosauria* established on the supposed double occipital articulation with the vertebral column and reestablished it on the characters given by Seeley for his *Pareiasauria* the name *Cotylosauria* should be dropped and the name *Pareiasauria* used.

In 1898, after Cope's death, appeared his revised "Syllabus of Lectures on the Vertebrata" (44), in which the family *Otocœlidæ* is separated from the *Cotylosauria* and placed in a new order, *Chelydosauria*.

In 1900 the United States National Museum published Cope's "Catalogue of the Crocodilians, Lizards, and Snakes of North America" (45), in which the same classification appears as in the last edition of his syllabus of lectures.

In the same year Hay's "Bibliography and Catalogue of the Fossil Vertebrates of North America" appeared as a bulletin of the United States Geological Survey (47). In this the *Cotylosauria* is considered as a distinct order with the families *Pariotichidæ*, *Diadectidæ*, and *Pareiasauridæ*.

In 1902 Eastman's translation of Zittel's "Grundzüge der Paleontologie" (71) gave

Order *Theromorpha* (*Anomodontia* Seeley non Owen).
Suborder 1. *Pareiasauria* Seeley (*Cotylosauria* Cope).
Family *Pareiasauridæ*.
Pariotichidæ.
Diadectidæ.

On December 29, 1902, Osborn and McGregor read a paper before the American Association for the Advancement of Science at the Washington meeting; the same paper was read before the New York Academy of Science on February 9, 1903. An abstract of this paper was published in "Science" for February 13, 1903 (54), by Osborn. In it was proposed the division of the Class Reptilia into two subclasses, the *Diapsida* and *Synapsida*.

Subclass Synapsida.	Subclass Diapsida.
Order *Cotylosauria*.	Order *Rhyncocephalia*.
Anomodontia.	*Dinosauria*.
Testudinata.	*Icthyosauria*.
Plesiosauria.	*Phytosauria*.
	Pterosauria.
	Squamata.
	Crocodilia.

In the same year Broom (8) proposed a division of the primitive Reptilia as follows:

Rhyncocephaloid Orders.	Theromorous Orders.
Order *Procolophonia*.	Order *Pareiasauria*.
Pelycosauria.	*Theriodontia*.
	Anomodontia.

The order *Pareiasauria* was divided into the families *Pareiasauridæ*, *Pariotichidæ*, and *Diadectidæ*.

In November of 1903 appeared Osborn's detailed paper on "The Reptilian Subclasses *Diapsida* and *Synapsida* and the Early History of the *Diaptosauria*" (55). The position of the *Cotylosauria* is the same as given in the preliminary papers by Osborn and McGregor.

Broili's description of the Permian collections in Munich appeared in the "Paleontographica" in 1904 (4). His arrangement of primitive reptiles is as follows:

Order *Rhyncocephalia.*
Lysorophus tricarinatus.
Order *Theromora.*
Suborder *Cotylosauria.*
Family *Pareiasauridæ.*
Genus *Labidosaurus, Seymouria.*
Family *Otocælidæ.*
Genus *Otocælus, Conodectes.*
Family *Diadectidæ.*
Genus *Diadectes, Empedias, Chilonyx, Bolbodon.*
Family *Pariotichidæ.*
Genus *Isodectes, Captorhinus, Pariotichus, Pantylus, Hypopnous, Helodectes.*
Order *Pelycosauria* (*Theriodontia*).

In 1904 Boulenger published a description of *Telerpeton elginense* (4), in which he suggested a diphyletic origin of the reptiles from the amphibia. In this paper Boulenger says:

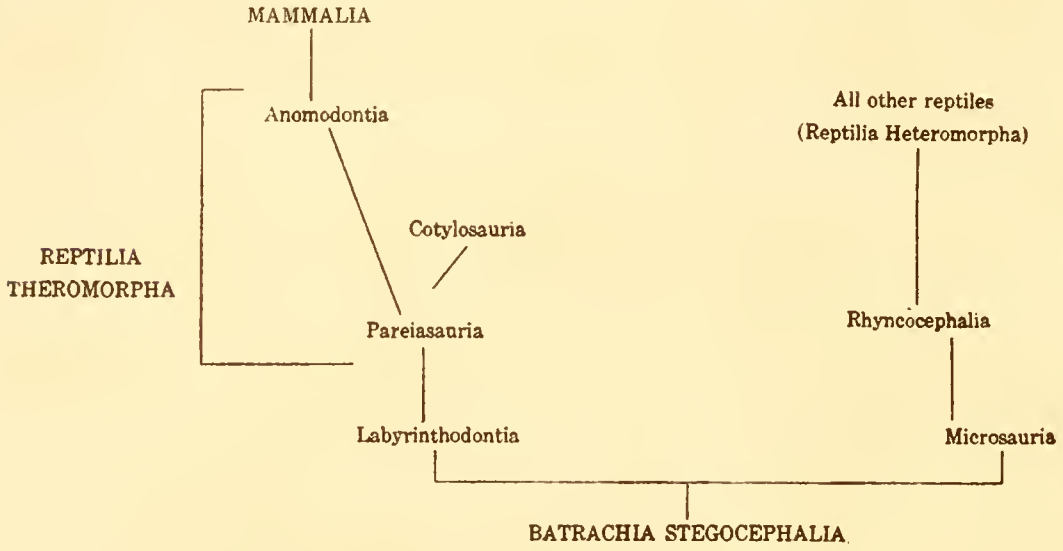
"What we know of the American *Cotylosauria* shows them to be a type closely related to the Pariosaurians, though differing from them in at least one important character, the absence of the cleithrum. The same may be said of the *Procolophonia* (*Procolophon* and *Telerpeton*), and therefore, these must be regarded, in the light of our present knowledge, as pertaining to the group for which the earlier *Cotylosauria* should be used.

"The order *Cotylosauria* may be defined as thecodont reptiles with the temporal region roofed over (without or with a single temporal foramen), with clavicles and interclavicle, with coracoids and precoracoids (epicoracoids), without or with a very vestigial plastron, and with the number of phalanges as in the typical reptiles. The absence of the cleithra and the presence of more than 2, 3, 3, 4, 3, phalanges distinguishes them from the *Pariosauria;* the second character and the roofing over of the postorbital part of the skull distinguishes them from the *Anomodontia;* whilst the presence of the ossified precoracoids and the absence or the extreme reduction of the plastron separates them from all the other primitive orders, such as the *Rhyncocephalia*, *Plesiosauria*, *Thecodontia*, etc., with the possible exception of the *Pelycosauria* which also flourished in the Permo-Triassic time.

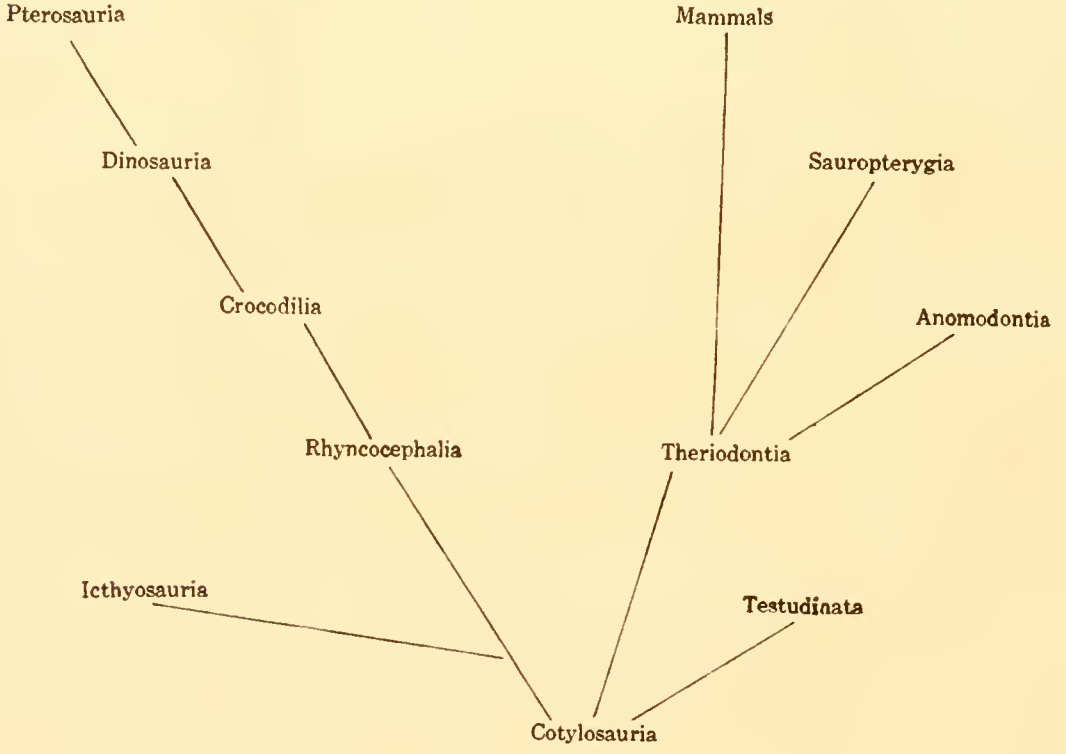
"The order *Cotylosauria* would comprise four families, the definition of the American types being derived from the contributions of Cope and Case.

"A. Supratemporal roof broad, orbit small, nearly in the middle of the length of the head; no latero-temporal vacuities; upper surface of the skull more or less sculptured.
Teeth small not transversely expanded, in two rows in the posterior part of the jaws ..... 1. *Pariotichidæ*
Lateral teeth large, with the crowns expanded transversely to the axis of the jaws in a single series ..... 2. *Diadectidæ*

"B. Supratemporal roof narrow, orbit very large; skull smooth; lateral teeth expanded transversely to the axis of the jaws.
No lateral temporal vacuity..... 3. *Telerpetidæ*
A small lateral temporal foramen..... 4. *Procolophonidæ*"



In 1904 Williston (64) raised objections to placing the *Cotylosauria* in Osborn's subclass *Diapsida* and asserted his belief that Cope was most nearly correct in his scheme proposed in 1896 in the "Primary Factors of Organic Evolution," in which the *Cotylosauria* are regarded as the most primitive reptiles. Following is Cope's scheme as indorsed by Williston:



In 1905 Case published two papers (**13**, **14**) in which he demonstrated the similarity of the *Diadectidæ* to the *Otocœlidæ* as defined by Cope, and suggested that the *Diadectidæ* be placed with the *Otocœlidæ* in the order *Chelydosauria*, leaving the families *Pariotichidæ*, *Elginidæ*, and *Pareiasauridæ* to form the *Cotylosauria*.

In 1908 Williston (**65**) showed that Case was not within the laws of nomenclature in making this proposition and that the name *Cotylosauria* must go with the *Diadectidæ*, wherever they were placed.

CLASSIFICATION.

The following arrangement seems to the author to be the most advisable in the present state of our knowledge of the group:

Order COTYLOSAURIA.
- Suborder *Diadectosauria.*
  - Family *Diadectidæ.*
    - Genus *Diadectes.*
      - *Bolbodon.*
      - *Chilonyx.*
      - *Diasparactus.*
      - *Desmatodon.*
      - *Diadectoides.*
  - Family *Bolosauridæ.*
    - Genus *Bolosaurus.*
  - Family *Nothodontidæ* (?).
    - Genus *Nothodon.*

INCERTAE SEDIS.
- Genus *Eosauravus.**
  - *Bathyglyptus.*

FOREIGN FORMS.
- Genus *Sauravus.**
- Suborder *Pareiasauria.*
  - Family *Pariotichidæ.*
    - Genus *Pariotichus.*
      - *Isodectes.*
      - *Ectocynodon* (?).

Order COTYLOSAURIA—Continued.
- Suborder *Pareiasauria*—Continued.
  - Family *Captorhinidæ.*
    - Genus *Captorhinus.*
      - *Labidosaurus.*
      - *Helodectes* (?).
  - Family *Seymouridæ.*
    - Genus *Seymouria.*
      - *Conodectes* (?).
      - *Stephanospondylus* (?).

FOREIGN FORMS.
- Family *Pareiasauridæ.*
  - Genus *Pareiasaurus.*
    - *Propappus.*
    - *Anthodon.*
    - *Elginia.*
    - *Phanerosaurus.*
    - *Sclerosaurus.*
- Suborder (?) *Procolophonia.*
  - Family *Procolophonidæ.*
    - Genus *Procolophon.*
      - *Thelegnathus.*
      - *Saurosternum.*
  - Family *Telerpetidæ.*
    - Genus *Telerpeton.*
- Suborder *Pantylosauria.*
  - Family *Pantylidæ.*
    - Genus *Pantylus.*

*It is believed that these two forms, from their lower geological position and primitive character may represent the most primitive type of the reptilia and should perhaps be placed in a separate order, but as the head is unfortunately missing in both specimens our knowledge is not sufficient to warrant any definite conclusion as to their position.

Attention is also called to the note at the end of the comparative tables (p. 66).

SYSTEMATIC REVISION.

Order COTYLOSAURIA Cope.

Cotylosauria Cope, Am. Nat., vol. xiv, 1880, p. 304.
Cotylosauria Cope, Am. Nat., vol. xxiii, 1889, p. 866.
Cotylosauria Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 436.

Original description: In 1880, in describing the skull of *Empedocles* Cope mentions the supposed peculiar method of articulation of the skull with the cervical vertebræ; this was due to the falling out of the basioccipital bone, giving the appearance of a double occipital condyle. Upon this error the order was founded. Cope says:

"The character of the articulation is so distinct from anything yet known among the vertebrated animals that I feel justified in proposing a new division of the *Theromorpha*, to include the *Diadectidæ*, to be called the *Cotylosauria*."

In the "American Naturalist" of 1889 Cope gives an analysis of the order on other grounds than the occipital articulation: "Ribs single-headed; temporal fossa overroofed; dentition abundant; intercentra."

In the "Proceedings of the American Philosophical Society" for 1896 he redescribed the *Cotylosauria:*

"Quadrate bone united by suture with the adjacent elements. Temporal fossa overroofed by the following elements: Postfrontal, postorbital, jugal, supramastoid (squamosal), supratemporal (prosquamosal), quadratojugal. Tabular bone present. Vertebræ amphicœlous; ribs one-headed. Episternum present. Pelvis without obturator foramen."

Revised description: Primitive reptiles with the temporal region complete; overroofed by two elements, squamosal and prosquamosal, or three, squamosal, prosquamosal, and quadratojugal. Quadrate covered or exposed. Ribs single-headed. Neural arches broad and low, the sides swollen and convex, spines short and stout.

The order is assumed to include all the early reptilia with complete skulls, indicating their primitive relationship to the *Stegocephalia*. It is meant to include the suborders *Diadectosauria*, *Pareiasauria*, *Procolophonia*, and *Pantylosauria*.

Suborder DIADECTOSAURIA nov.

1. Skull completely overroofed with the exception of the posterior angle, where the quadrate and the external auditory opening are exposed.
2. Upper end of the quadrate bent backward and downward in a hook. The external face of the quadrate concave, forming a funnel with the apex at the notch formed by the hook described.
3. Temporal region covered by two bones, squamosal and prosquamosal.
4. External process of the pterygoid absent or poorly developed; edentulous.
5. Parasphenoid rostrum not appearing on the lower surface of the skull between the pterygoids.
6. Ectopterygoids absent or rudimentary.
7. Tabulare absent or doubtfully present.
8. Cheek teeth expanded transverse to axis of jaw A single row in each jaw.
9. Hyposphene-hypantrum articulation present.
10. Coracoid and procoracoid united with the scapula. Cleithrum present.
11. Ischium and pubis broad and plate-like.
12. Abdominal ribs absent (?), not observed in any specimen.*

*The characters of the revised description of the orders, suborders, families, and genera are arranged with serial numbers, the same for each group, so that they can be compared directly

Family DIADECTIDAE Cope.

Cope, Am. Nat., vol. XIV, 1880, p. 304.
Cope, Proc. Am. Phil. Soc., vol. XIX, 1880, p. 45. Also Pal. Bull. 32.
Cope, Proc. Am. Phil. Soc., vol. XX, 1882, p. 448.
Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 439.
Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 130.
Case, Jnl. Geol., vol. XIII, 1905, p. 126.

Original description: "American Naturalist," 1880:

"The relations of the quadrate and zygomatic arches are as in the *Theromorpha* generally. The pterygoids extend to the quadrates and the vomer bears teeth. The brain case extends to between the orbits, and the lateral walls are uninterrupted by fissures from this point to near the origin of the *os quadratum*. There is an enormous frontoparietal foramen. The mode of connection with the atlas is peculiar. There is a facet on each side of the *foramen magnum*, which then expands largely below them. The bone which bounds it inferiorly presents on its posterior edge a median concavity. On each side of this is a transverse cotylus, much like those of an atlas which are applied to the occipital condyles of the *Mammalia*. They occupy precisely the position of the mammalian condyles. The median point of their upper border, which forms the floor of the foramen magnum, is produced in the position occupied by the median occipital condyle of a reptile. From its position between the cotyli, the section of this process is triangular. The element in which the cotyli are excavated has the form of the mammalian basioccipital, and of the reptilian sphenoid. It is not the batrachian parasphenoid. Its extreme external border on each side where it joins a crest descending from the exoccipital, is excavated by a circular fossa which looks outward."

In 1882 Cope added (p. 448):

"The sacrum consists of two vertebræ only, and is thoroughly united with the pelvis by its transverse processes. The latter are decurved on the inner side of the iliac bones, and the sutures which distinguish them from the latter and from each other are not serrate. The inferior arch is robust, but very narrow anteroposteriorly. The acetabulum is entire in every respect, so that it is probable that both pubis and ischium are united indistinguishably in the arch. The pubis is perforated by the usual internal femoral foramen. The posterior edge is grooved, and it might be suspected that this marks the articulation of an ischium. The anterior edge is, however, grooved in the same way, so that the appearance is rather the position of muscular insertion. The spines of the sacral vertebræ are distinct, and have the usual form seen in the *Diadectes*."

In 1896 Cope gives the following table of characters and list of genera:

"I. Posterior maxillary teeth transverse, depressed, molariform, the heel (external above, internal below) broad and flat. Skull without dermal or osseous sutures *Empedias* Cope.
II. Posterior maxillary teeth compressed, transverse, with non-molariform edge or apex, except on wear.
a. Teeth with an external heel, besides the apical cusp.
Cranial bones coossified; dermal scuta few or none . . . . . *Diadectes* Cope.
aa. Teeth with a cusp only.
Adult cranium sutureless . . . . . *Bolbodon* Cope.
Cranium with osseous but no dermal sutures . . . . . *Phanerosaurus* v. M.
Cranium with both osseous and dermal sutures . . . . . *Chilonyx* Cope."

Revised description (in addition to the characters given in the revised description of the order):

1. Surface of the skull rugose or tuberculate.
2. Pineal eye enormous.
3. Occipital condyle flat or concave.
4. A more or less complete armor of plates overlying the ribs. Perhaps a median row of plates overlying the neural spines.
5. Anterior ribs, at least, expanded into wide plates.
6. Body low and heavy; neck extremely short; limbs short and stout.
7. Tail moderately long, with strong chevrons.

It has been shown by the author (13) that the *Diadectidæ* possess many of the characters assigned by Cope to the family *Otocœlidæ* and the order *Chelydosauria*, and for this reason the *Diadectidæ* were placed in the *Chelydosauria*, but as this has been shown to be in contravention of the rules of nomenclature the assignment must be altered. The *Diadectidæ* is here referred to its proper place in the *Cotylosauria* and many of the characters originally assigned to the *Chelydosauria* are used in the description of the *Cotylosauria* and *Diadectidæ*. As will be shown later, the order *Chelydosauria* must be transferred to the *Amphibia*. *Otocœlus*, the type of the order and the family, turns out to be an amphibian, while *Conodectes*, though evidently a reptile, is so imperfect that it is impossible to make an accurate and sufficient description, and is tentatively placed with *Seymouria* Broili.

In this paper there are considered as members of the family *Diadectidæ*: *Diadectes*, *Chilonyx*, *Bolbodon*, *Desmatodon*, *Diasparactus*, and *Diadectoides*. *Empedias* is eliminated as an indeterminate form; it was separated from *Diadectes* on the character of the presence of canine teeth, but no specimen assigned to either genus by Cope shows canine teeth. The teeth are mostly indicated in the region by empty alveoli and it is impossible to determine whether the larger alveoli were occupied by large canines or by large incisors.

Genus DIADECTES Cope.

Diadectes Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 505. (Also Pal. Bull. No. 29.)
Diadectes Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 441.
Diadectes Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, pp. 131 and 133.
Empedocles Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, pp. 516 and 529. (Also Pal. Bull. No. 29.)
Empedocles Cope, Proc. Am. Phil. Soc., vol. XIX, 1880, p. 45.
Empedias Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 634.
Empedias Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 441.
Empedias Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 131.

Type: A rough fragment of a left lower jaw with but two perfectly preserved teeth and two broken ones; also fragments of indeterminate vertebræ. No. 4360 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Teeth with short and much compressed crowns whose long axis is transverse to that of the jaws. Edges of the crown obtuse, with tuberosities on some of them, distinct from the principal apex. The latter is worn off very obliquely by attrition in all of the specimens. The crowns covered with an enamel-like substance which has no especial sculpture. Alveoli not separated. The external alveolar border in each jaw more elevated than the internal, and in the superior series, at least, diverges from the tooth line backwards and outwards. The surface of attrition descends outwards in the maxillary series, and rises inwardly in the dentary series. A large fossa pierces the inner alveolar border just behind the inner extremity of each tooth.

"The affinities of this very singular form can not yet be determined. The mandibular ramus rises directly from the posterior extremity of the dental series, showing that there is a coronoid elevation of the bone, as in the *Dinosauria*. The teeth are received in deep alveoli. It is probable that the vertebræ are amphicœlous. The animals belonging to this genus were, in all probability, herbivorous."

In the "Proceedings of the American Philosophical Society" for 1896, vol. XXXIV, p. 441, Cope gave the presence of a canine tooth as the distinguishing mark of *Diadectes* as opposed to *Empedias*. Later in the same year (Proc. Am. Phil. Soc., vol. XXXV) he suggested the more depressed and molariform character of the cheek teeth of *Empedias* as a distinguishing character.

Genus EMPEDIAS Cope.

(This genus is not determinable, but the description is introduced because in it is given the character of the hyposphene and hypantrum.)

Type: Numerous vertebræ, four in series. No. 4351 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Both dorsal and cervical vertebræ possess centra of the general character of *Clepsydrops*, with small intercentra. The neural arches present important differences. There is on the posterior aspect, below the zygapophyses a well-developed hyposphen, and on the anterior face a correspondingly strong hypantrum. The structure is identical with that which I have described in the genera *Camarasaurus* and *Amphicœlias*, but is rather better developed. It disappears at some posterior point of the dorsal series. The zygapophyses are much elevated, and spread apart in *Empedocles*, and are connected back to back. From this junction the diapophysis depends, forming a vertical septum whose inferior extent is greatest on the cervical, and least on the dorsal vertebræ. It is undivided, and there is no capitular facet on the centrum, the rib had but a single head. The expansion of the diapophyses with that of the posterior zygapophyses gives to the posterior side of the vertebræ a remarkable appearance, and forms an oblique roof above the centrum. The neural spine is not elevated, and is very robust, being in some cases greater in the transverse than in the anteroposterior diameter, again approximating remotely, *Camarasaurus*. Of the dentition nothing is known, but some jaws with teeth of animals allied to *Clepsydrops* may belong here."

In 1880, from the study of three imperfect skulls, Cope adds the following to the characterization of *Empedias:* "Molar teeth in one series. No canine."

In 1883 he adds that "the species of *Empedias* form a series which diverges from *Diadectes* by a successive widening of the crowns of the teeth and a diminution in their number."

In 1896, p. 441, he gives in a comparative table: "Teeth less compressed, robust; no canine; os tabulare not produced; top of head without dermal scuta."

In vol. XXXV of the "Proceedings of the American Philosophical Society" for 1896, p. 131, he gives a totally new classification of the *Diadectidæ* and announces the following characters for *Empedias:* "Posterior maxillary teeth transverse, depressed, molariform, the heel (external above, internal below) broad and flat. Skull without dermal or osseous sutures."

Revised description: In addition to the characters given in the description of the family and the order:

1. Cheek teeth, from the middle part of the series, with three distinct cusps. The number of cheek teeth variable. Tooth line sigmoid.
2. Skull with coarse, rugose sculpture; not tuberculate.

3. The third, fourth, and fifth ribs expanded into broad triangular plates. The sixth, seventh, and eighth overlain by slender plates.
4. Transverse processes of the vertebræ extending beyond the zygapophyses.

There seems to be no valid reason for retaining the genus *Empedias*. As explained in the description of the family, the genera were separated largely on the character of canine teeth. More than once Cope altered his definition of the genus as his opinion of the value of the presence or absence of the supposed canines and of the more or less molariform character of the cheek teeth varied. The condition of the specimens does not permit a successful effort to separate them into two groups according to Cope's description and so the genus *Empedias* is dropped.

Diadectes sideropelicus Cope

Proc. Am. Phil. Soc., vol. XVII, 1878, p. 505.
Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 133.

Type: The same as that of the genus.

Original description: "The lateral tuberosity of the teeth already described is on the most elevated, hence opposite, borders of the crowns in the two jaws. It differs in its degree of prominence in different teeth, but is subject to attrition in one of the jaws at least. The form of the principal worn surface is an elongate oval. The investing layer of the crown is perfectly smooth, excepting between the lesser and the greater cusps, where the obtuse edge is slightly longitudinally grooved. The surface of the jaws is not sculptured.

"*Measurements.*

	M
"Greatest elevation of a tooth (No. 1)	0.011
Diameters of crown:	
Transverse	.006
Anteroposterior	.012
Four teeth occupy	.042
Four alveoli of (specimen) No. 2 occupy	.024

"The jaws are as large as those of a medium sized alligator."

In 1896 Cope showed that the specimen No. 2 was a distinct species (see *D. biculminatus*) and redefined *D. sideropelicus:*

"This species is represented by a left maxillary bone which contains three molar teeth in place and spaces for five or six others. A simple tooth at its anterior part is larger than is usual in the species of this family. I have accordingly defined the genus *Diadectes* as characterized by the presence of a canine tooth. It is, however, not possible to determine whether the other simple teeth may not have been of equal proportions, as they are represented by the alveoli in the specimen. I therefore define the genus by the molar characters, which are distinct. In this respect the species *D. latibuccatus* and *D. phaseolinus* agree with it. In the last named the heel of the molars is larger than in the two others, approaching remotely the genus *Empedias*. The *D. latibuccatus* differs from the *D. sideropelicus* in the smaller number of the molar teeth, and more numerous caniniform teeth."

Revised description: The type specimen is a fragment of the left side of the lower jaw instead of a portion of the maxillary, as described by Cope. The whole specimen is in a wretched state of preservation and there are three imperfect teeth. The crowns of all are so worn that it is impossible to distinguish them from other species of the genus. The species is indeterminate.

Diadectes phaseolinus Cope. (Plate 1, figs. 6, 6a.)

Diadectes phaseolinus Cope, Proc. Am. Phil. Soc., vol. XIX, 1880, p. 46. (Also Pal. Bull. No. 32.)
Diadectes phaseolinus Cope, Am. Nat., vol. XV, 1881, p. 164.
Empedias phaseolinus Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 634.
Empedias phaseolinus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 442.
Diadectes phaseolinus Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 132.

Type: Described as the maxillary bones of three animals and the mandible with most of the tooth line of a fourth; a single maxillary and a single vertebra now preserved. No. 4349 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The molars possess a low cusp which is nearly in the middle of the tooth. Of the lower and external cusps, the internal is wider and more rounded; when unworn it is as elevated as the external, but it is soon reduced by attrition. The external part of the tooth is somewhat narrowed, and there is no horizontal surface on either side of the median cusp, as in *Empedocles molaris*. The last maxillary tooth is rather small; preceding it are eight wide transverse ones, and then two less extended transversely before reaching the broken end of my best specimen. The anterior of these is elongate, and may be caniniform, but its apex is lost. External layer smooth; some wrinkles around the base of the median cusp.

"The broken base of the malar bone is subround and small, and shows that the element is slender below the orbit.

"The portion of the mandible preserved is quite deep, and is incurved at the symphysis. But few of the teeth are preserved, and it is not possible to say how long the anterior ones with subround bases may have been. The molar whose crown is preserved does not differ materially from those of the maxillary series. The alveolar line does not retreat inwards from the external border as in *Empedocles latibuccatus*, resembling in this respect the *D. sideropelicus*. The external surface of the lower jaw is roughened by shallower and deeper small or minute pits placed closely together.

"*Measurements.*

	M
"Length of a series of eleven maxillary teeth	0.075
Length of a series of seven widest molars	.048
Diameter widest molar:	
Anteroposterior	.006
Transverse	.016
Depth of mandible externally	.050
Width of mandible at middle	.026"

Revised description: The median cusps of the posterior molars are more conical, not extending across the crown of the tooth. The inner half of the tooth is swollen more than the outer; the inner cusp is larger, more rounded, and a little higher than the other. The inner cusp joins the median one more sharply than does the outer.

Diadectes molaris Cope. (Plate 1, figs. 5, 5a.)

Diadectes molaris Cope, Am. Nat., vol. XII, 1878, p. 565.
Empedocles molaris Cope, Proc. Am. Phil. Soc., vol. XIX, 1880, p. 47.
Empedias molaris Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 634.

Type: A fragment containing two large teeth and the base of third. No. 4347 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Paratype: A fairly complete skull lacking the basioccipital region. No. 4350 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description of type: "The teeth are more completely molar in their character than the species already described (*E. alatus*), being in the unworn condition as broad across the crown as the latter is high. In the transverse direction the crowns are two and a half times as long as wide. The extremities are rounded, and there is a median cusp extending across the crown; on each side of the cusp, the face of the crown is slightly concave. The enamel is strongly but finely wrinkled. The series terminate abruptly in a tooth of half the transverse extent of the penultimate. Length of space occupied by the penultimate and ante-penultimate teeth M. .021; length of base of the penultimate .010; width of do. .024; elevation of crown, least .006; do. at cusp, .009.

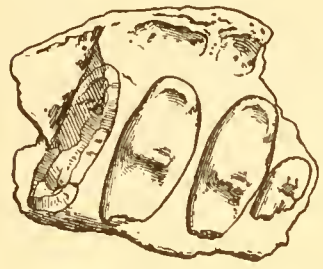


FIG. 1.—Two maxillary teeth of *Diadectes molaris*. × 1. Type No. 4347 Am. Mus.

"This species is larger than those heretofore described, and the teeth are adapted for crushing harder bodies—having perhaps a use like those of *Placodus* or *Pycnodus*. It is called *D. molaris*."

Original description of paratype ("Proceedings American Philosophical Society," 1880, p. 47):

"The molar teeth are wider in this species than in any species of the family yet known. The internal and external extremities of the crown are about equally wide and equally elevated, and there is a low median cusp. A portion of the grinding surface, both internal and external to the cusp, is horizontal; the surface of this portion is wrinkled. The last molar is smaller than the others. The inner border of the maxillary bones forms a curved ridge on each side of the palate, which is separated by a groove from the vomer. The latter forms a median keel at the anterior portion of the palate, where it supports two rows of small conical teeth. The palatines have their prominent internal edges juxtaposed as far as the transverse line of the last molars. There they diverge a little, and extend as two nearly parallel keels to a prominent angle on each side, opposite the middle of the zygomatic foramen. There the inner borders cease to project, and are directed obliquely outwards to the inner extremities of the quadrate bones. The external borders of the pterygoids are more elevated than the internal. The median keel of the basisphenoid arises between the internal angles of the pterygoids above mentioned, and ceases before reaching the inferior border of the occipital condyle. The external border of the exoccipital is sigmoidally flexed. * * *

"*Measurements.*

	M
"Total length of the skull	0.180
Width of the skull at quadrates	.145
Width of skull at origin of the zygoma	.115
Width of skull at incisive foramen	.056
Length of dental series to posterior extremity of incisive foramen, on curve	.090
Diameters of third molar:	
Anteroposterior	.010
Transverse	.021
Depth of mandible at fifth molar from behind	.048"

Revised description: The teeth in the type specimen are larger than in any other of the specimens and it is probable that the larger skulls without the teeth preserved belong here, as No. 4352 Am. Mus. Nat. Hist. Cope Coll. There is much of the original description that is valueless and only the portion referring to the teeth has been quoted.

Teeth broader; median cusp wedge-shaped, extending across the crown; internal and external cusps nearly equal in size and separated by a considerable area from the median cusp.

Diadectes biculminatus Cope. (Plate 1, fig. 4.)

Diadectes biculminatus Cope, Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 132.
Specimen No. 2 of Diadectes sideropelicus, Proc. Am. Phil. Soc., vol. xvii, 1878, p. 505.

Type: A fragment of a mandible with two complete teeth. No. 4374 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: The teeth are "remarkable for their compressed form, and for the unequal elevation of the grinding surface. There is a median cusp much elevated above an external heel, which is at the base of the crown; and there is an internal cusp which is fused to the median cusp, and reaches a similar elevation. It is doubtful whether there are any interalveolar walls, as the teeth are closely placed. The internal cusp is a little more elevated than the median, and its apex is separated from that of the latter by a shallow notch. The outer wall of the median cusp is vertical, while the inner wall of the inner cusp is convex both vertically and anteroposteriorly. The worn section of the two is unequally dumbbell-shaped. The external face of the median cusp exhibits a median rib, with a groove on each side, besides finer grooves, which are also present on the anterior faces of the crown near the external border. Internal to these, the median cusp sends shallow grooves obliquely inwards and downwards, which do not reach the base of the internal cusp. The transverse diameter of the crowns diminishes gradually posteriorly, so that the alveolus of the last one of the series is small and round. * * *

"*Measurements.*

	M
"Length of series of nine teeth	0.046
Width of crown of largest molar	.013
Elevation of external heel	.005
Elevation of internal cusp	.011
Anteroposterior diameter	.005
Width of mandibular ramus at do	.026"

Revised description: The teeth are narrow anteroposteriorly, with the inner end slightly wider than the outer. The outer cusp is very low, and the median and inner cusps (of equal height) are much more elevated than the outer.

Diadectes fissus Cope. (Plate 1, figs. 1, 2, 2a.)

Proc. Am. Phil. Soc., vol. xx, 1883, p. 634. (Also Pal. Bull. 36.)
Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 132.

Type: Two individuals. A maxillary with dentition and a fragmentary skull, No. 4348 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Superior teeth wider, 14 on each side, the last the largest, sphenoid not keeled." "The *Empedias fissus* is nearest the *E. molaris* and has the same number of teeth. It differs, however, in various essential points. The last maxillary tooth, which is much reduced in size in the *E. molaris*, is here as large as any of the others. The portion of the crown within the median cusp is fissured medially in the direction of its length; that is, transversely to the axis of the jaws. This fissure is not so distinct in the mandibular teeth. The median cusp has a straight edge at right angles to the long axis of the crown. The specimens where the entire dental series of one side is preserved shows that the latter has a sigmoid flexure, the middle of the maxillary bone being incurved, and the anterior part being convex outwards. There are five or six conic teeth between the incisors and the molars. * * *

"*Measurements.*

"No. 1.

	M
"Length of last six superior molars	0.055
Diameters of antepenultimate molar:	
Anteroposterior	.010
Transverse	.020
Diameters of crown of incisor:	
Vertical	.013
Transverse (at base)	.007
Anteroposterior	.011

"No. 2.

Length of dental series in a straight line	.093
Width of palate at anterior expanse	.062
Width of palate at contraction	.068
Width of palate between widest molars	.036"

Revised description: It is evident that in his description Cope mistook the lower jaw for the upper; the mistake is very pardonable, as the bones are badly crushed and the basisphenoid and basioccipital bones lie between the jaws. The teeth resemble those of *D. molaris;* the median cusp is wedge-shaped, extending across the crown; the outer cusp is wider than the inner; both the inner and the outer cusps are separated from the median one by a nearly flat space. The outer cusp is crossed transversely by a sharp, very narrow groove which practically divides it into two tubercles. This groove is visible on the outer but not on the inner side of the median cusp. The inner cusp is divided less perfectly by a wider and more shallow groove. In the upper teeth the cusps are divided by wide and shallow grooves.

Empedias alatus Cope.*

Proc. Am. Phil. Soc., vol. xvii, 1878, p. 516.

Type: Several vertebræ, the same as the genus.

Original description: "The diapophyses are not long, and their articular surfaces are quite elongate downwards and forwards, especially on the cervical centra. On the more posterior dorsals, the diapophysis arises exclusively from the neural arch, but maintains its very narrow oblique articular face. On all the vertebræ the centrum is about as long as wide, with regular marginal angles without bevel for intercentrum. The sides are concave, and the inferior median line horizontal, and thickened. The neural spine is short in the dorsals, and with a subquadrate section, with the angles lateral and anteroposterior. The apex is excavated at the extremity. The space between the planes of the opposite zygapophyses is strongly convex. The latter have horizontal faces. In other vertebræ the neural spine is more transverse, and the zygapophyses are separated on the median line by a smaller fossa on the anterior face of the arch and a larger one on the posterior face.

"In a specimen in which the hyposphen has disappeared, it is represented by a ridge connecting the posterior zygapophyses, which is decurved over the neural canal.

"*Measurements.*

"No. 1, dorsal vertebra of the smaller individual.

	M
"Total elevation of the vertebra	0.105
Elevation of the centrum	.029
Elevation of the zygapophyses	.060
Elevation of the base of neural spine	.083
Width of apex of neural spine	.025

* This species appears in Cope's lists of 1881 and 1888, but after that is not listed by him, as it became apparent that it was indeterminate.

Measurements—Continued.

"No. 1, dorsal vertebra of the smaller individual—Continued.

	M
Vertical extent of extremity of diapophysis	0.036
Diameter of centrum:	
Anteroposterior	.026
Transverse	.027
Width between inferior extremities of tubercular facets of diapophyses	.066
Width between extremities of zygapophyses	.082
Length between extremities of zygapophyses	.042

"No. 2, a larger individual.

"Total elevation	.130
Diameter of centrum:	
Anteroposterior	.029
Transverse	.043
Vertical	.039
Extent of zygapophyses	.102
Elevation of neural spine	.026"

Diadectes latibuccatus Cope.

Diadectes Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 505.
Empedocles Cope, Am. Nat., vol. XIV, 1880, p. 304.
Empedias Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 634.
Empedias Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 442.
Diadectes Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 131.

Type: A fragmentary maxillary bone. No. 4377 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "On comparison with the corresponding portion of the jaw of *D. sideropelicus*, the following characteristic marks appear: The tooth line diverges much more strongly inwards from the maxillary border in the *D. latibuccatus*, leaving a wide groove between the two. This groove is separated by a narrow horizontal partition from a corresponding one on the superior face of the same element, and its surface is longitudinally roughened. The teeth are closely placed, and the series turns with the anterior extremity of the jaw, abruptly inwards. The transverse diameter of the teeth lessens to just posterior to the point of curvature, so that their section is nearly round; at and anterior to the curve, the wide transverse diameter is resumed, the last alveolus preserved making an angle of 45° with those in the posterior part of the jaw. The external surface of the maxillary bone is roughened, as is also the case in the *D. sideropelicus* with coarser and finer irregular impressions, fossæ, and grooves.

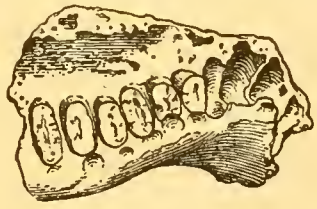


FIG. 2.—Anterior half of right maxillary of *D. latibuccatus*. × ¾.
Type No. 4377 Am. Mus.

"*Measurements.*

	M
"Width of jaw at ninth tooth from curve	0.036
Width of ninth tooth from curve	.011
Width of fourth tooth from curve	.006
Width of tooth at curve	.008
Width of third tooth anterior to curve	.010
Width of jaw at curve	.019
Elevation of alveolar part of jaw	.018
Three teeth in	.015"

In the "American Naturalist" for 1880 Cope referred this species to the genus *Empedocles*, apparently having decided that the anterior teeth were incisors and not canines.

In the "Proceedings of the American Philosophical Society" for 1883 the name *Empedias* is used, as *Empedocles* was found to be preoccupied. In this paper Cope gives additional characters of the species:

"The species of *Empedias* forms a series which differs from *Diadectes* in a successive widening of the crowns of the teeth and diminution in number. Thus the *E.* (written *D.*) *phaseolinus* is nearest to the *Diadectes; E.* (written *D.*) *molaris* succeeds it, and in *E. fissus* we have the molariform character most strongly developed. In the *E. latibuccatus*, on the other hand, the diminution of the transverse extent of many of the teeth and the areolar sculpture of the superior surface of the cranium points in the direction of the genus *Chilonyx*. The species of *Empedias* may easily be distinguished as follows:

"I. Surface of the skull divided by grooves into areæ.
Superior teeth, 16 on each side, a number on each end of the maxillary bone of little transverse extent . . . . . *E. latibuccatus*
II. Surface of the skull uniformly rugose.
Superior teeth narrower, 16 on each side, the last one small, sphenoid flat, pterygoids narrow . . . . . *E. phaseolinus*
Superior teeth wider, 14 on each side, the last one smaller, the sphenoid keeled medially, pterygoids wide . . . . . *E. molaris*
Superior teeth wider, 14 on each side, the last the largest, sphenoid not keeled . . . *E. fissus.*"

In 1896 the genera of the *Diadectidæ* were redefined and the *E. latibuccatus* with the species *phaseolinus* was restored to the genus *Diadectes*.

Revised description: It is admittedly dangerous to form species in vertebrate paleontology, and especially is this true when dealing with such distorted material as occurs in the beds of Texas, where almost every specimen could be described as a new species—or with a little more latitude almost every specimen of a genus could be retained in a single species. The teeth are more apt to present determinable characters and the foregoing discriminations have been based entirely upon them. In the type specimen of *D. latibuccatus* only the bases of the teeth are preserved and in the second specimen used by Cope in his descriptions, No. 4353 Am. Mus. Nat. Hist. Cope Coll., but a single one near the posterior end of the series has any portion of the crown preserved. This tooth looks something like those of *D. biculminatus*, but it is very uncertain. The larger number of teeth, seventeen, in the maxillary, and the more numerous smaller teeth with nearly round section at the base, in the region of the maxillary-premaxillary suture, are the only distinguishing characters.

Diadectes maximus Case.

Bull. Am. Mus. Nat. Hist., vol. XXVIII, art. XVII, 1910, p. 174.

Type: Three large vertebræ. No. 4392 Am. Mus. Nat. Hist. Cope Coll. From Texas.

A large number of isolated bones in different collections indicate the presence of a very large member of the genus *Diadectes*. Size alone, however, is not sufficient to indicate specific difference in the reptilia where growth is practically continuous through life. These vertebræ, from the posterior portion of the column, show a distinct difference from the other members of the genus in the position of the hyposphene and hypantrum. The faces are nearly horizontal instead of being sharply oblique.

Measurements.

	mm
Distance from bottom of posterior face of centrum to base of spine	146.5
Height of the posterior face of the centrum	58.5
Length of bottom of centrum	48
Width across posterior zygapophyses	140

An anterior caudal vertebra, field No. 252 Am. Mus. Nat. Hist. collection of 1908, of appropriate size to go with the type specimens, measures 182 mm. from the base of the centrum to the top of the spine. The width across the transverse processes to the point of origin of the ribs is 83 mm.

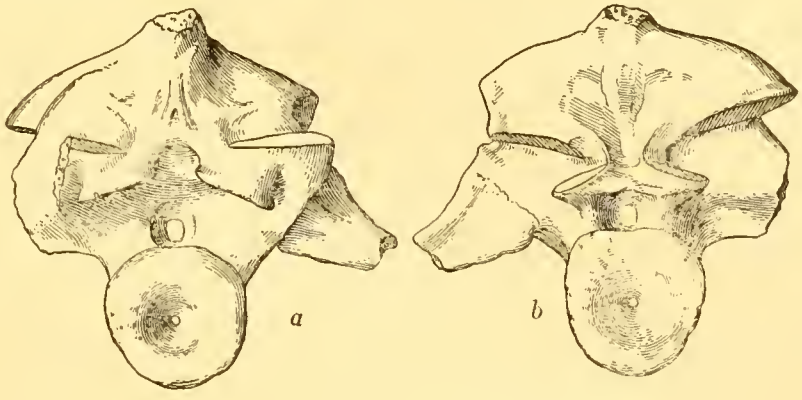


FIG. 3.—Dorsal vertebra of *D. maximus*. × $\frac{1}{3}$. Type No. 4392 Am. Mus.
a, anterior view; *b*, posterior view.

Genus DIASPARACTUS Case.

Diasparactus zenos Case.

Bull. Am. Mus. Nat. Hist., vol. XXVIII, art. XVII, 1910, p. 174.

Type: A few connected vertebræ from the posterior portion of the precaudal series. No. 4797 Am. Mus. Nat. Hist. Cope Coll. From New Mexico.

The vertebræ are the last presacrals and two sacrals. They are characterized by the small size of the centra compared with the height and width of the neural arch and zygapophyses. The transverse processes are so short that they do not extend out from the centrum as far as the zygapophyses. The last perfect vertebræ of the series, reckoned as the first sacral, shows a peculiar abnormal condition; the transverse process of the right side is very small and there is no face for the attachment of a rib, on the left side the transverse process is large but very short and there is a large face for a sacral rib. An imperfect vertebra behind this one shows a reverse of this condition; this is evidently a case of abnormal attachment of the pelvis.

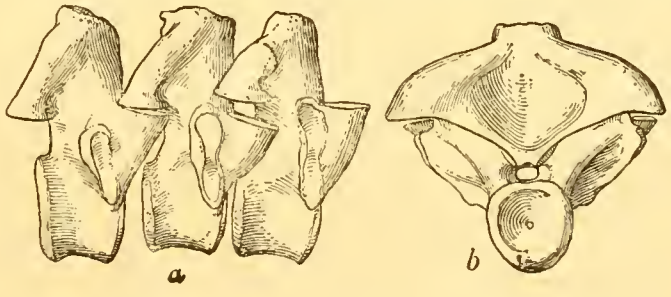


FIG. 4.—Vertebræ of *Diasparactus zenos*. × $\frac{1}{2}$. Type No. 4797 Am. Mus.
a, lateral view of three posterior dorsals; *b*, posterior view of a vertebra.

The first presacral has only a very short transverse process without any face for the attachment of a rib. The second has a very short face on the transverse process; this face is inclined forward as in *Diadectes*, but only very slightly so, and the upper

end only very slightly overhangs the lower. In *Diadectes* the face is inclined sharply downward and forward. In the more anterior vertebræ the face on the transverse process grows in length, but the process itself remains so short that it may almost be considered as absent and the articular face attached to the posterior surface of the anterior zygapophysis.

Measurements.

	mm
Transverse diameter of a centrum at the middle	23
Transverse diameter of the same at the bottom	12
Anteroposterior diameter of same	20
Height of same vertebra to the base of the spine	63
Width across the posterior zygapophyses	66
Width across zygapophyses anteroposteriorly	37

Genus BOLBODON Cope.

Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 134.

Type: Half of a skull, showing only the dermal bones of the roof. No. 4375 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Molar teeth without external heel and with one median cusp. Cranial bones coossified; no grooves indicating the sutures of dermal scuta. Internal borders of the palatine bones in mutual contact, and dentigerous.

"The dentition of the genus is not different from that of *Phanerosaurus*, as described and figured by Geinitz and Deichmüller. In that genus, according to the authors, the cranial elements are distinct, the sutures being persistent. In *Bolbodon* the cranial elements are entirely coossified, excepting only the tabular bone, which is distinguishable. The nostril is large, and a turbinal bone is visible within it as in *Pariotichus*. The lateral and inferior bones of the brain case, and the mandible, are not preserved."

Bolbodon tenuitectus Cope. (Plate 10, fig. 1.)

Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 134.

Type: Same as the genus.

Original description: "From the middle line at the apex of the vomer to the posterior extremity of the maxillary bone there are alveoli for seventeen teeth. Of these, six only are occupied by teeth, which are Nos. 5, 7, 10, 12, 13, 16. Of these only 5, 13, and 16 have perfect crowns. The skull has been somewhat distorted by pressure, so that the longer axis of the roots and crowns are somewhat oblique to their correct positions. The roots of Nos. 5 and 7 are wide oval in section, and the long axis becomes longer posteriorly up to No. 16, in which it is a little contracted, and where the entire dimensions are smaller. The crown of No. 5 is caniniform and acute (the crown of this tooth is missing in the present condition of the specimen), is curved backwards as to its anterior face, and has a worn posterointernal face due to the opposing tooth of the inferior series. In No. 13 the crown is much more expanded transversely, and the external border is convex medially and incurved above and below. Curved shallow grooves radiate from the external (?) apex downwards and inwards. The crown of the sixteenth tooth is cordiform, with the acute apex upwards. Shallow grooves descend from the latter. Like the maxillary teeth the palatines are widely spaced. The sections of their crowns are a wide oval placed longitudinally; apices lost.

"The nostril is large and is rounded subquadrate. The orbit is large and is subround, and its border is not notched as in the *Diadectes latibuccatus*, nor the

superior border depressed as in *D. phaseolinus*. The interorbital space is gently convex, and is wider than the diameter of the eye, but how much wider the state of the specimen leaves uncertain. The jugal bone is quite narrow below the orbit, its vertical diameter equalling two-fifths that of the latter. The surface of the cranium is rather minutely wrinkled, and does not display the grooves seen in the *Diadectes latibuccatus*. The tabular bone forms a rounded and narrowed cap of the posterolateral angle of the skull, and is much less prominent than in the genus *Chilonyx*, but more so than *Diadectes*, where it is not distinguishable by suture.

"*Measurements.*

	M		M
"Total length of the cranium from the premaxillary to the os tabulare inclusive	0.284	Diameters of fifth tooth:	
Diameters of the nostril:		Longitudinal	0.015
Vertical	.025	Anteroposterior	.007
Transverse	.033	Transverse	.010
Distance from nostril to orbit	.078	Diameters of the twelfth tooth:	
Diameters of orbit:		Longitudinal	.013
Vertical	.053	Anteroposterior	.0065
Tranverse	.054	Transverse	.013
Interorbital width (posterior to middle)	.070	Diameters of the sixteenth tooth:	
Length of dental series (chord)	.150	Longitudinal	.010
		Anteroposterior	.005
		Transverse	.0085

"The dimensions of this skull are equal to those of *Diadectes phaseolinus*, and about one-fourth larger than those of *Diadectes latibuccatus*. The bones of the cranium are thinner and lighter than those of any other species of the family that has come under my observation."

Revised description of the genus and species: The genus and species is based on a single lateral half of a skull; no other specimens are known. Closely related to *Diadectes*, it is distinguished by the greater thinness of the bones of the skull and the less rugose sculpture of the surface. The differences in proportions, from *Diadectes*, may readily be accounted for by the conditions of preservation; most of the skulls of *Diadectes* have been preserved more or less entire and have been subjected to pressure from above downward, the skull of *Bolbodon* was split in the median line before fossilization and subjected to lateral pressure. The tooth figured by Cope is the posterior one of the series and is not characteristic; in all of the species of *Diadectes* the posterior tooth is smaller and more simple than the more anterior ones.

Genus CHILONYX Cope.

Bolosaurus rapidens Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 507.
(Also Pal. Bull. No. 29.)
Chilonyx Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 631.
Trans. Am. Phil. Soc., vol. XVII, 1892, p. 13.
Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 441.
Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 131.

Type: An imperfect skull. No. 4357 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Teeth with the long diameter of the crowns transverse to that of the jaws, and with the crown contracting to a single slightly incurved apex. Maxillary series of teeth short. Temporal fossæ overroofed. Superior surface of the cranium divided into more or less swollen areas by grooves.

"The single species of this genus is one of the largest saurians yet obtained in the Permian of North America."

In 1896 Cope describes *Chilonyx* as follows:

"Teeth compressed, with an apex; no canine; os tabulare produced into a tuberosity or horn; top of head scutate."

Chilonyx rapidens Cope. (Plate 10, fig. 2.)

Bolosaurus rapidens Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 507.
Chilonyx rapidens Cope, Proc. Am. Phil. Soc., vol. XX, 1883, p. 631.

Type: A single tooth from the posterior or middle portion of series. No. 4356.

Paratype: No. 4357 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The size is many times greater than that of the species of this genus (*Bolosaurus*) already described, and it is uncertain whether the posterior tooth possesses the internal ledge characteristic of them. The anterior tooth does not possess it. The transverse diameter of the crown is considerably greater than the anteroposterior, and the convexity of the outer side is without facets. One side of the curve is flatter than the other. The enamel is perfectly smooth. The inner face is occupied by the surface of attrition of the corresponding tooth of the opposite jaw. The supposed anterior tooth is from another locality. Its section is similar to that of the present tooth, and the enamel is similarly smooth. The cutting edges are both smooth, and bounded by a little groove next the plane inner face. The crown is much more elevated than that of the tooth first described, and is in general shaped like a claw. It may be from the pterygoid bone of another genus.

"*Measurements.*

	M
"Elevation of the crown (axial)	0.010
Diameter of crown:	
Anteroposterior	.006
Transverse	.008"

In the "Proceedings of the American Philosophical Society" for 1883, p. 631, Cope gives a characterization as follows:

"The superior surface of the skull is everywhere flat, as is the external face of the maxillary. The surface of the latter is marked by moderately coarse fossæ and grooves, separated by more or less fine irregular but generally longitudinal ridges. The minute sculpture of the superior cranial surface is finer and more punctate in character. The areæ of this surface, already mentioned, are arranged as follows: There is a series over the orbits, which are separated from each other by straight grooves, and which grow larger and more swollen posteriorly. Between the supraorbital rows, the areæ of the top of the skull are separated by longitudinal grooves, except immediately between the orbits, where there are some narrow transverse areæ. On the supraoccipital region there is a median subtriangular area, and three narrow longitudinal ones on each side of it. External to these, and on the posterior part of the squamosal region, the areæ are larger and more swollen. A cluster of three of these lies between the exoccipital bone, and the smooth descending surface of the posterior edge of the squamosal. Of these the one bounding the exoccipital bone is a robust cone, forming a short horn, like that occupying a similar place in the horned toad, *Phrynosoma douglassi*. Between the temporal areæ, and in front of the supraoccipital areæ, on each side of the middle line, there are three longitudinal areæ, which are successively narrower externally, the exterior being very narrow. On the frontal region, anterior to the transverse areæ, are two wide longitudinal areæ. Each nasal bone has a small median area, from which radiate grooves, of which some of the posterior are close together.

"The occiput is excavated into a large fossa on each side of a large triangular supraoccipital region. The fossæ are bounded externally by a strong exoccipital crest and at the anteroinferior corner by the 'ophisthotic.' This bone projects posteriorly and downwards, in the form of a robust hook. The foramen magnum is not excavated so abruptly above the exoccipital facets as in *Empedias molaris*.

"*Measurements.*

	M
"Interorbital width	0.108
Length from supraoccipital crest to frontonasal suture	.135
Width between apices of tuberosities of the intercalaria	.113
Length from apex of tuberosities to inferior extremity of quadrate	.129
Diameters of quadrate condyle:	
Anteroposterior	.020
Transverse	.039
Length of maxillary on alveolar edge	.087
Diameters of base of a posterior tooth:	
Anteroposterior	.007
Transverse	.010
Diameters of base of another posterior tooth:	
Anteroposterior	.005
Transverse	.010

"A femur, which is included in the lot of specimens, has a wide head without trochanters, convex in the plane of the distal condyles and flat in the direction at right angles to it. There is a huge trochanteric fossa extending from the head two-fifths the length to the condyles, bordered by a ridge on each side. The condyles present in the same direction as the fossa posteriorly. They are separated by a deep anterior and posterior emargination. Their anterior edges overhang the condylar articular surfaces, making acute angles with them. One of the articular surfaces is smaller, is anteroposteriorly extended, and has a convex ectad, and concave entad border. The other surface is also anteroposterior, reaching further distad, but not so far proximad as the other. Its area is greater than that of the other, and it is deeply notched by the entering surface of the bone ectad and proximad. It is then contracted into a wide isthmus, and the lateral grooves which produce this isthmus are overhung by the expansion of the anterior face. The anterior face of the femur is without ridges or processes.

Fig. 5.—No. 4357 Am. Mus. Anterior view of right femur of *Chilonyx*. × ⅓.

"*Measurements.*

	M
"Length of femur	0.236
Proximal diameters of femur:	
Anteroposterior	.047
Transverse	.085
Width of shaft	.052
Width distally (greatest)	.115"

Revised description of the genus and species: The teeth described as the type are imperfect incisors and might belong to any species of the genus *Diadectes*. The

genus and species rest on the paratype; they are distinguished by the larger size and the tuberculate condition of the bones of the skull. There are no lines indicating the attachment of scutes as described by Cope.

Genus DESMATODON Case. (Plate 8, fig. 2.)

Desmatodon hollandi Case, Annals Carnegie Museum, vol. IV, Nos. III and IV, 1908, p. 236.

Type: A fragment of a maxillary bone with four teeth and the root of a fifth. No. 1938 Carnegie Museum. From Pitcairn, Pennsylvania.

Original description: "The teeth are of peculiar interest, as they represent an intermediate stage between those of *Bolbodon* and those of *Diadectes*. They seem to indicate with little doubt the existence of a new genus which may be called *Desmatodon hollandi*. The teeth are transversely elongate; the crown is slightly wider than the root and is also somewhat swollen in the anteroposterior direction. The outer half of the crown rises gently into a sharp apex, from which there is a sharp descent to the inner half, which is lower than the outer half. The inner side of the apex is nearly vertical and presents a flat face inwards; this is more prominent on the posterior and largest of the teeth than on the anterior ones. The surface of the crown is marked with fine lines and the sides of the root show the same character, but here the lines are coarser. The inner half of the crown of the anterior and the posterior teeth shows no wear, but on the two in the middle there are surfaces worn by attrition on both the inner half of the crown and on the apex. The relation of this genus to its nearest related forms is indicated in the figure here given." (See fig. 34.)

Revised description: This genus is closely related to the genus *Diadectes*, but the differences in size and character and also its geographical and geological separation from the Texas beds make it advisable to regard it as distinct.

Genus DIADECTOIDES nov.

Diadectoides cretin sp. nov.

Type: A vertebral column, nearly complete, with ilium, femur, tibia and fibula, and fragments of the skull. No. 650 University of Chicago. From Willbarger County, Texas.

This skeleton resembles that of *Diadectes* in many respects and might at first be considered as a young individual of that genus, but the proportions of the limbs, the shape of the apices of the spines, and the free neural arch indicate a distinct genus. The bones are covered with a hard matrix which permits the general form to be made out, but conceals minor details. It was only after considerable study that it was possible to be certain of the presence of hyposphene and hypantrum.

Fig. 6 is after an original by Dr. Williston, who most kindly turned the specimen over to me after having begun work upon it.

The single sacral vertebra is the sixteenth of the series preserved; it is certain that the number of presacrals is incomplete, probably four or five are wanting.

The *dorsal vertebræ* are, as in *Diadectes*, very similar throughout the series. The spines are short and low, but instead of terminating in rugosities as in *Diadectes*, they terminate in flat oval surfaces. The sides of the neural arch are swollen and convex, as in *Diadectes*. The zygapophyses are horizontal; the neural arches are wider than long, and the zygapophyses overlap so far as to bring the spines in contact. The result is a short, heavy, vertebral column with very little possibility of lateral motion. Hyposphene and hypantrum appear to have been present but are obscured by the matrix at most places. The neural arches fit so closely upon each

other that the hyposphene-hypantrum articulation can not be seen from the side, as in *Diadectes*. The transverse processes are similar to those of *Diadectes*, having single faces inclined downward and forward to the upper edge of the centrum. The neural arches are free from the centra, which are detached in most parts of the column. The lower edges of the neural arches are rounded and appear to have been attached to the centrum by a considerable mass of cartilage. The centra are deeply biconcave or notochordal; the lower surface can not be clearly made out, but there seems to have been a broad, low median keel. No intercentra can be made out, but small ones were undoubtedly present.

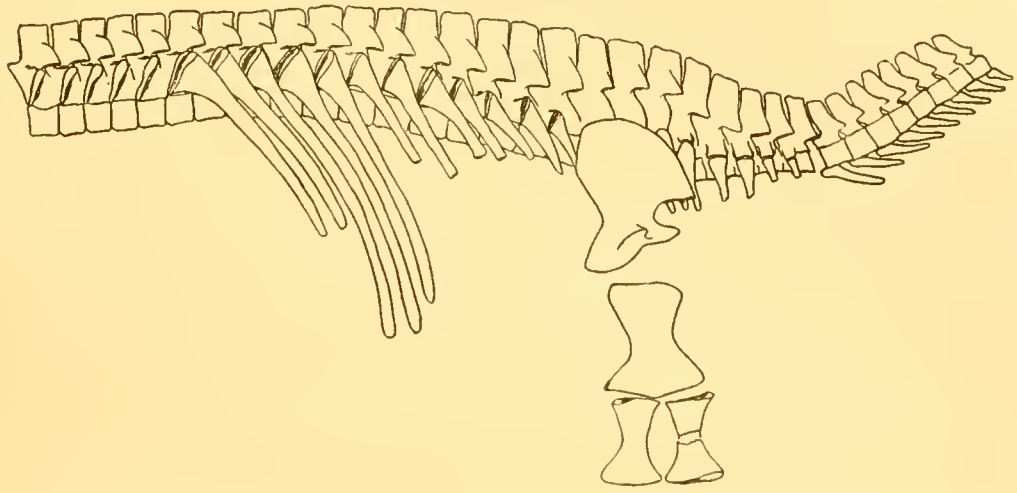


FIG. 6.—Outline of part of vertebral column of *Diadectoides cretin*. × ⅓. Univ. of Chicago.

The *sacral vertebra* resembles the others in the neural arch and spine, except that the posterior zygapophyses are reduced in size and this portion of the neural arch is thinner. The transverse process, however, presents a very large face almost directly downward, for the head of the sacral rib. The centrum is not attached to that of the following vertebræ; there is no sacrum.

Posterior to the sacral vertebra there are fourteen *caudal vertebræ*. The apices of the spines of the first are more elongate oval and they rapidly decrease in size. The transverse processes do not have elongate faces slanting forward and downward, but round, rather large faces looking outward but largely downward. Chevrons appear on the fourth or fifth; these are short, bifurcate above, and inclined to the rear. The neural arches and centra are narrower in this region and the whole tail was flat and high.

The *ribs* are single-headed, long, and slightly curved; free ribs occur on all the presacral vertebræ preserved; there were no true lumbars. The sacral rib is very short and heavy; the proximal end was attached by two wide faces to the transverse process and the centrum; there is practically no shaft and the distal end is expanded into an elongate oval, with its main axis vertical, applied to the inner side of the ilium. The first caudal ribs were free, but they soon disappear.

The *ilium* is short and stout with a slightly convex anterior edge and a prominent posterior projection. A good-sized process overhangs the acetabulum. The attachment of ischum and pubis was sutural.

The *femur* is exceptionally short and strong. The upper end presents a nearly flat articular face; there is a prominent process on the posterior face near the anterior

end, in the position of the concavity of most reptilian forms. This is most striking and leads to some doubt as to the correct identification of the bone; it resembles the tibia of other forms, but is far too large to be a tibia of this creature, and as both bones are present and show this character, its determination seems certain. The shaft is short and thick, the lower end is imperfectly divided into two faces.

The *tibia* is similar in form to that of *Diadectes* and resembles quite closely the femur in general form. The lower end has two distinct faces at an angle of 45°.

The *fibula* is probably represented by the two ends; little can be made out beyond its exceptional heavy form.

Fragments of the skull with some poorly preserved teeth show that the skull was in general form like *Diadectes*.

Measurements.

	mm
Length of the series of vertebræ	380
Length to posterior end of sacral vertebra	230
Length of ilium on midline	54
Length of femur	47
Width of distal end of femur	37
Length of tibia	36
Length of a mid dorsal rib	127
Length of an anterior chevron	24

This creature seems to have carried the peculiarities of *Diadectes* to an extreme. The vertebral column is more closely knit and even shorter. The limb bones are heavy and very short. The tail was moderately long, but very thin and fairly high. The whole appearance must have been that of a short, low, and very wide creature with broad stumpy legs. The evident great strength, coupled with the essential weakness of the free neural spines, leads to the suggestion that the specimen is that of an immature animal.

Family BOLOSAURIDAE Cope.

Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 529.
Case, Bull. Am. Mus. Nat. Hist., vol. XXIII, 1907, p. 652.

Original description: "*Bolosaurus* will form the type of another family characterized by the transverse position of the crowns of the teeth, under the name *Bolosauridæ*."

Revised description (Case, 1907): "Small Cotylosaurians with the cheek teeth elongate transversely and with a prominent cusp, in the upper series on the outer edge and in the lower series on the inner edge; the cusps showing slight wear in mature specimens. The family is distinguished from the *Pariotichidæ* by the presence of the cusps on the teeth and by the presence of but a single row in the lower jaw, and from the *Diadectidæ* by the presence of an elongate parasphenoid rostrum and a prominent outer process of the pterygoid bearing a row of teeth on the lower edge."

Revised description:

1. Skull smooth or slightly rugose.
2. Pineal foramen small.
3. Occipital condyle rounded.
4. No armor.
5. Ribs not expanded.
6. Body low; limbs short, not heavy.
7. Not determinable.

Genus BOLOSAURUS Cope.

Bolosaurus Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, pp. 506 and 529.

Type: An imperfect posterior portion of a skull. No. 4320 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Teeth fixed in shallow alveoli, and with the crowns expanded transversely to the axis of the jaws. The crowns swollen at the base, and with low apex, divided vertically into two equal portions. The posterointernal half in the maxillary series is low and horizontal; the anteroexternal portion forms a low cusp, which has a semicircular section. The teeth of the lower jaw are similar, but the relative positions of the ledge and cusp are reversed. Anterior teeth of superior series composed of external cusp and internal ledge. No enlarged canine or incisor teeth. Bones of face not sculptured."

Revised description: This is contained in the revised description of the family.

Bolosaurus striatus Cope. (Plate 7, figs. 4, 5, 6.)

Bolosaurus striatus Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 506.
Bolosaurus striatus Case, Bull. Am. Mus. Nat. Hist., vol. XXIII, 1907, p. 653.

Type: Same as that of the genus.

Original description: "*Char. Specif.* The external surface of the crown is marked to the apex with waved grooves of the enamel. The edge of the elevated cusp, which presents posteriorly in the maxillary teeth, constitutes the abrupt termination of the exterior face, and is serrate by the interference of the sulci. The edge of the basal ledge is slightly serrate. The muzzle is rather elongate, and the sides of the maxillary and dentary bones are plane and smooth. The mandible is rather narrow, and forms a narrow wedge in the profile outline. It rises posteriorly behind the dental line. The teeth are separated by intervals as wide as a tooth.

"*Measurements.*

	M
"Long diameter of orbit No. 1	0.0130
Depth of upper jaw at orbit	.0045
Depth of lower jaw at front of orbit	.0050
Four teeth in	.0080
Elevation of a crown	.0025
Transverse diameter of molar number 2	.0025"

The foregoing description, by Cope, was evidently taken in large part from the type skull, but some portions of the description are evidently taken from a second skull, No. 4321 Am. Mus. Nat. Hist. Cope Coll., and perhaps from other specimens.

He adds: "A slight modification of the character is found in two imperfect crania. The principal character is to be seen in the teeth. The enamel of the external surface of the cusps is not sulcate, but is smooth; and the posterior cutting edge of the cusp is much less distinct. It is, in fact, obtuse and not serrate. The orbit is large, and the front and muzzle are regularly decurved to the premaxillary border. The angle of the mandible is moderately prominent, and is massive and obtusely truncate. The interorbital region is flat in the transverse direction.

"*Measurements.*

	M
"Length of the skull to the mandibular angle	0.050
Length of the skull to the orbit	.015
Long diameter of the orbit	.018
Width of the interorbital region	.009
Six teeth in	.010"

Revised description: This is contained in the revised description of the family.

Family NOTHODONTIDAE Marsh.

This family was established without diagnosis.

Genus NOTHODON Marsh.

Am. Journ. Sc., vol. xx (3), 1899, p. 410.

Type: A portion of the skull and some limb bones. Yale University Mus. From New Mexico.

Original description: "These reptiles may be readily distinguished by the dentition. In each premaxillary there are two slender pointed teeth. In front of the maxillary there are one or two similar teeth, followed by a number with narrow transverse crowns, resembling in form the premolars of some carnivorous mammals. These crowns, when unworn, have a central cusp, and on each side a tubercle, somewhat like the premolars of the genus *Canis*. In the present species the first and last of the teeth are smaller than the middle ones. The limbs were short, the long bones had their extremities covered with cartilage, but the carpals and tarsals were well ossified. The centra were deeply concave and the tail was long.

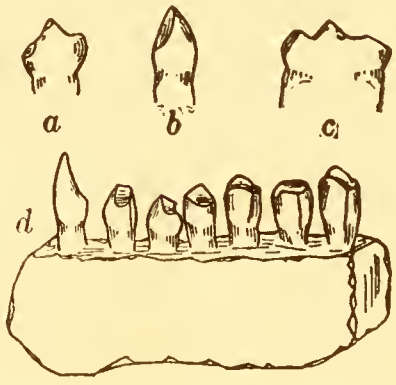


FIG. 7.—*a*, *b*, *c*, three teeth of *Nothodon lentus*. Yale Univ. Mus. *d*, the same, a fragment of maxillary. × 1.

"The following measurements are taken from the type specimen of this species:

	M
"Length of the maxillary bone	0.065
Space occupied by ten maxillary teeth	.015
Height of crown of second maxillary tooth	.014
Height of crown of third maxillary tooth	.009
Anteroposterior diameter	.003
Transverse diameter	.008
Anteroposterior diameter of the eighth tooth	.005
Transverse diameter	.015

"The present species was about 5 or 6 feet in length, and herbivorous in habit. It was apparently slow in movement, and probably more or less aquatic."

Nothodon lentus Marsh.

The description of this species is embodied in that of the genus.

Revised description: This family with its genus and species was founded on extremely fragmentary material from New Mexico. The association of the teeth with other parts of the skeleton is more than doubtful. The teeth closely resemble those of *Diadectes*, but in view of the wide geographical separation from the locality where *Diadectes* occurs and of the possible stratigraphical separation, it seems best to retain the family provisionally until more is known of the skeleton.

INCERTAE SEDIS.

EOSAURAVUS Williston.*

Eosauravus copei Williston.

Isodectes punctulatus Cope, Proc. Am. Phil. Soc., vol. xxxvi, p. 88.
Isodectes copei Williston, Journ. Geol., vol. xvi, 1908, p. 395.
Isodectes punctulatus Moody, Proc. Nat. Mus., vol. 37, 1909, No. 1696, p. 11, pls. 4 and 5.

Type: The plesiotype of *Isodectes punctulatus*. The posterior portion of a small skeleton. No. 4457 U. S. Nat. Mus. From Linton, Jefferson County, Ohio.

Description abstracted from Williston's account of this specimen in the "Journal of Geology," 1908.

Twenty-three dorsal vertebræ indicated, with perhaps one or two more. Ribs small, slender and curved, moderately dilated at the proximal extremity; all attached intervertebrally. Vertebræ amphicœlous and doubtless notochordal. No indica-

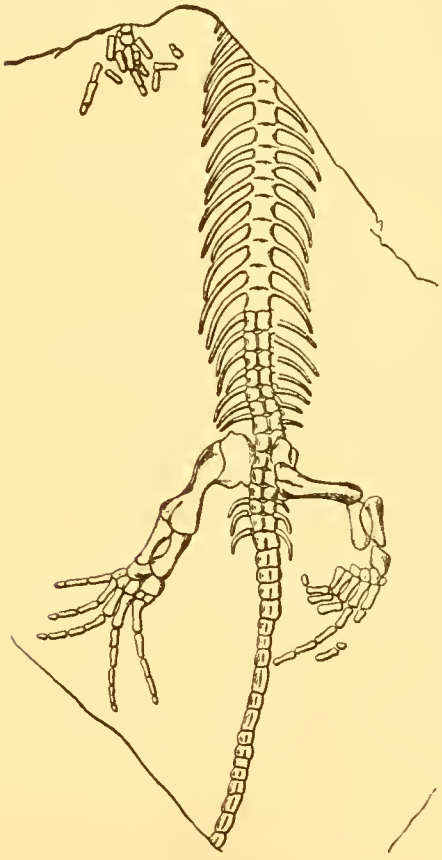


Fig. 8.—Outline of *Eosauravus copei*. After Moody.

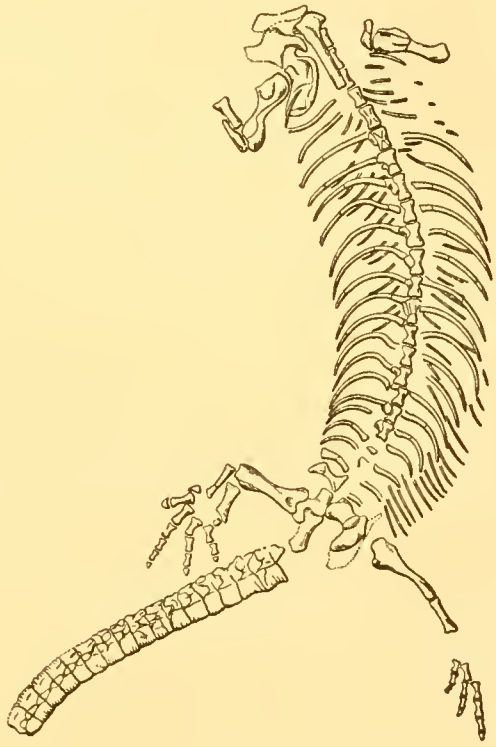


Fig. 9.—Outline of *Sauravus costei*. After Thevinin.

tions of a ventral armor. No intercentra preserved, but these are doubtless present. Two sacrals. Tail long and slender. Tarsus as in accompanying figure; phalanges 2, 3, 4, 5, 4. Terminal phalanges with claws.

To the description given above should be added that the neural arches are low and broad with horizontal zygapophysial faces and short, heavy spines. The

* This name was proposed by Dr. Williston in a letter to the author, dated December 18, 1909.

absence of abdominal armor may well remain in doubt. Williston and Moody have shown it to be absent in this specimen, but it has also been absent in many of the specimens from the Permian and finally has been found to have been present. In fact, the abdominal ribs would be one of the first things to disappear, as the soft abdominal wall inclosing them would be loosened by the decay of the intestines. There is no certainty that the abdominal ribs were absent and much probability that they were present.

Genus BATHYGLYPTUS nov,

Bathyglyptus theodori sp. nov.

Type: Fragments of two lower jaws. Field No. 250 Am. Mus. Nat. Hist., Expedition of 1908. From Willbarger County, Texas.

The jaws belonged to an animal considerably larger than any of the well-known forms of the family *Diadectidæ*. The teeth are broken at the base, and with the exception of one or two are poorly preserved. The roots of the teeth indicate that they were of equal size, except a single tusk at the anterior end, and that all were round in section. The jaw might be taken for that of a large Pelycosaur, but it is much heavier and more rugose than that of any known form. It resembles that of the *Diadectidæ* much more closely, but it is distinguished from that family by the round teeth. There are nineteen teeth, which was probably the complete number.

Measurements.

	mm
Length of longest fragment of jaw	311
Probable length of jaw	375-400
Anteroposterior diameter of largest tooth at base	21
Breadth of same	17

FOREIGN FORMS.

Genus SAURAVUS.

Sauravus costei Thevinin.

Annales de Paléontologie, Paris 1, Heft. 3, 1906.

This specimen was found in the upper part of the Stephanien of France, near Blanzy (Saone-et-Loire). It most unfortunately lacks the skull, but a good part of the skeleton of the body is preserved. The vertebræ are notochordal; the neural spine is low and coossified with the centrum. Intercentra were not observed, but large spaces between the lower edges of the centra indicate their presence, possibly in a cartilaginous state. There were twenty-three or twenty-four dorsal vertebræ, two sacrals, and at least seventeen caudals. The ends of neural arches and hæmapophyses are striated as in *Keraterpeton* from the Permian of Nyran in Bohemia. All presacral vertebræ bear ribs and there are abdominal ribs present. The interclavicle is T-shaped. The humerus has the proximal and distal ends almost at right angles and there is no entepicondylar foramen (?). The tarsus has fibulare, tibiale, and five distal tarsalia. The phalangeal formula of the posterior foot was probably 2, 3, 4, 5, 4.

Suborder PAREIASAURIA Seeley.

1. Skull completely overroofed.
2. Quadrate concealed.
3. Temporal region covered by two bones.
4. External process of the pterygoid present in American forms (unknown in *Pareiasaurus*), with numerous small teeth.
5. Parasphenoid appears on the lower surface of the skull as a prominent rostrum between the pterygoids.
6. Ectopterygoid absent.
7. Tabulare present, often small.
8. Cheek teeth obtusely conical; one or more than one row in the upper and lower jaws.
9. Hyposphene-hypantrum articulation absent.
10. Coracoid and procoracoid united with the scapula.
11. Ischium and pubis broad and plate-like.
12. Abdominal ribs present or absent.

Family PARIOTICHIDAE Cope.

Proc. Am. Phil. Soc., vol. xx, 1883, p. 631.
Proc. Am. Phil. Soc., vol. xxxiv, 1896, pp. 439 and 442.

The family *Pariotichidæ* was established by Cope in 1883 to include the genera *Pariotichus*, *Pantylus*, "and probably *Ectocynodon*"; it was defined as follows: "Teeth like the *Edaphosauridæ*, but differs from it in the entire overroofing of the temporal fossæ."

The *Edaphosauridæ* was defined as having more than one row of teeth on parts of the jaws.

In 1896 he gave a tabular statement of the characters of the families of the order *Cotylosauria*.

"I. Teeth in a single series.
Teeth not transversely expanded; vertebral centra with surfaces only ossified; no hyposphen . . . . . *Elginidæ*.
Teeth not transversely expanded; vertebral centra ossified; no hyposphen . . . *Pariasauridæ*.
Teeth with the crowns transverse to the axis of the jaws; vertebræ ossified and with a hyposphen-hypantrum articulation . . . . . *Diadectidæ*.
II. Teeth in more than one series in (one or) both jaws.
Teeth with cylindric roots; vertebræ ossified . . . . . *Pariotichidæ*."

The family, as defined by Cope, was based almost entirely upon forms which are in this paper referred to the genus *Captorhinus* and which are regarded as belonging in a separate family. The characters assigned by Cope to his family *Pariotichidæ* are transferred to the new family, *Captorhinidæ*, and the family *Pariotichidæ* is redefined. Under the new definition it is made to contain the genera *Pariotichus*, *Isodectes*, and the doubtful form *Ectocynodon*.

Revised description:

1. Small; skull rounded anteriorly, flattened, amphibian in appearance. Fine sculpture on the bones of the skull.
2. The basioccipital and basisphenoid united and forming a large plate on the base of the skull.
3. Incisor teeth not enlarged. One or two cheek teeth anterior to the orbit sharply larger than the rest. More than one row in the jaws.

Only the skull known.

Genus PARIOTICHUS Cope.

Pariotichus Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, pp. 508 and 529. (Also Pal. Bull. 29.)
Ectocynodon Cope, Proc. Am. Phil. Soc., vol. XX, 1882, p. 450. (Also Pal. Bull. 35.)
Pariotichus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 443.

Type: A skull which has lost the outer layer of bone and the occipital region. No. 4328 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Homotype. A second skull in good condition. No. 4760 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The temporal fossæ were covered by a roof continuous with the postorbital region; the zygomatic arch extends low down, producing a resemblance to certain tortoises. The orbits are small and lateral, and the muzzle is short, with terminal nares. Their exact character can not be ascertained. The teeth are rooted, and have compressed obtuse crowns, with cutting edge; they diminish in length posteriorly and do not display any elongate canine. The cranial bones do not exhibit any sculpture."

In 1883 "Proceedings American Philosophical Society" (p. 631) this last statement was corrected: "The surface of the cranium has been mostly weathered away in the type of *Pariotichus, P. brachyops*, and I suspect that it is really sculptured and not smooth, as I originally stated."

In 1896 an analytical table of the genera of the *Pariotichidæ* was given. In this table the genus *Ectocynodon* is united with *Pariotichus* and many of the species of *Captorhinus* are regarded as belonging in the genus.

"I. External nostrils lateral.
a. Palatal and splenial teeth with compressed crowns.
Teeth equal, acute . . . . . *Isodectes* Cope.
Teeth increasing gradually in length anteriorly . . . . . *Captorhinus* Cope.
Teeth enlarged on the middle of the maxillary and anterior part of the incisive series . . . . . *Pariotichus* Cope.
aa. Palatal and splenial teeth obtuse, forming a grinding pavement.
Median maxillary and anterior incisor teeth enlarged . . . . . *Pantylus* Cope.
II. External nostrils inferior.
Mouth posterior in position, mandible short, and with a few acute teeth . . . *Hypopnous* Cope.
"It is probable that *Helodectes* Cope pertains to this family."

Revised description: See description of *Pariotichus brachyops.*

Pariotichus brachyops Cope.

Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 508; Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 445.

Type: An imperfect skull. No. 4328. Am. Mus. Nat. Hist. Cope Coll. From Texas.

Homotype: A skull. No. 4760 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The interorbital width is twice the diameter of an orbit, and is nearly flat. The cheeks behind the orbits are swollen; the canthus rostralis is obtuse, broadly rounded, and somewhat depressed; the nostrils were not large. The orbits are subround, and measured half of the length of the muzzle measured axially above. The mandibular rami are not deep. The longest teeth are below and in front of the anterior border of the orbit; posterior to this point they diminish rapidly and are reduced to a very small size. The crowns of the greater number of the teeth are short and much compressed, and the enamel is coarsely longitudinally grooved. An anterior mandibular tooth has a subconic crown.

"*Measurements.*	M
"Width of the skull at the parietal region	0.020
Length of skull from parietal region	.022
Interorbital width	.010
Four teeth in	.004
Length of root and crown of a tooth	.002"

In 1896 Cope added to his description of this species:

"The long maxillary tooth below the anterior half of the orbit. Head short, wide; orbit small, half interorbital width; length of skull about 25 mm."

Revised description of the genus and species:

1. Skull low and rounded anteriorly, resembling that of the Amphibia.
2. Orbits large and located at the middle of the skull.
3. Teeth more sharply conical than in the *Captorhinidæ*, but less so than in the Amphibia.
4. One or two cheek teeth anterior to the orbit sharply larger than the others. Incisors not enlarged.
5. Teeth probably in more than one row in both upper and lower jaws, but no evidence.
6. Basioccipital and basisphenoid large and forming a broad plate on the base of the skull.
7. Supraoccipital plates standing nearly vertical at the back of the skull.
8. Surface of the skull with fine sculpture.

9, 10, 11. Not determinable.

The type specimen is in very poor condition, showing little more than the general outline and a few maxillary teeth. The homotype is in much better condition. Its measurements are as follows:

	mm
Length	20.5
Anteroposterior diameter of orbit	6.
Interorbital width	4.5
Breadth of skull at posterior border	14.

Genus ECTOCYNODON Cope

Ectocynodon Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 508. (Also Pal. Bull. 29.)
Pariotichus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, pp. 446 and 447.

Type: An imperfect skull. No. 4345 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "*Char. Gen.* Cranium short and wide, with large postfrontal bones and a large orbit. Cranial bones sculptured, but no lyra. Teeth rhizodont, with elongate compressed crowns with anterior and posterior cutting edges. One of these between the orbit and nostril larger and longer than the others, and lying outside of the closed dentary bone. Mandibular symphysis not sutural, but ligamentous. Terminal mandibular tooth not small. Teeth not faceted, simple.

"This genus, which I suppose to be reptilian, is represented by a specimen which lacks the posterior portion of the skull; hence its near affinities can not be determined. In the character of the cranial sculpture it resembles crocodiles, and the Labyrinthodont genera cotemporary with it, and differs from *Lacertilia* with cranial sculpture known to me."

This does not include the definition given of *Ectocynodon incisivus* (31) which belongs in the genus *Captorhinus*.

Ectocynodon ordinatus Cope.

Ectocynodon ordinatus Cope, Proc. Am. Phil. Soc., vol. XVII, 1878, p. 508. (Also Pal. Bull. 29.)
Pariotichus ordinatus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, pp. 446 and 447.

Type: A fragment of a skull. No. 4345 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "Parietal and frontal regions flat, the latter joined to the maxillary by a rectangular canthus. Interorbital region wide, equal to the diameter of the orbit. Sculpture of vertex in longitudinal series of pits of considerable irregularity. There are ten or twelve such rows between the orbits. The crowns of the teeth are obtuse, and their surface smooth.

"*Measurements.*	M
"Interorbital width of skull	0.009
Width between prefrontal borders	.014
Depth of facial plate of maxillary	.007
Depth of ramus mandibuli at orbit	.006
Depth of ramus mandibuli near end	.003
Length of short maxillary tooth	.0015
Length of long maxillary tooth	.0030
Width of long maxillary tooth	.0015

"The skull of this species is about as large as that of *Heloderma suspectum*."

Revised description of the genus and species: The condition of this specimen makes it impossible to give a comparative list of characters; it is a mere fragment of a skull in very poor condition. The shape of the fragment indicates that the skull was wider than that of *Pariotichus*, and sculptured in a very different pattern. Between the orbits, the only place where the sculpture is preserved, the lines are arranged in a very regular basket pattern (see fig. 10). The character of the teeth appears to be quite the same as in *Pariotichus*. Cope considered the enlarged cheek tooth to be farther forward than in *Pariotichus* and called it a canine, but this does not seem at all certain.

FIG. 10.—Top of skull of *E. ordinatus*. ×1. Type No. 4345 Am. Mus.

This genus and species is, without doubt, different from both *Pariotichus* and *Isodectes*, but the specimen is so imperfectly preserved as to be almost indeterminate. It is retained provisionally only.

Genus ISODECTES Cope.

Pariotichus Cope, Proc. Am. Phil. Soc., vol. xx, 1883, p. 630.
Pariotichus Cope, Trans. Am. Phil. Soc., vol. xvii, 1892, p. 14, fig. 3, pl. 1.
Isodectes Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 442.
Isodectes Cope, Proc. Am. Phil. Soc., vol. xxxv, 1897, p. 88, fig. 3, pl. iii.

Type: An imperfect skull. No. 4329 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: This skull was originally referred to the genus *Pariotichus* (see the description of *Isodectes megalops* following) and repeatedly described as such, but in a tabular statement of the genera of the *Pariotichidæ* published in 1896 Cope gave the new name with the following characters: "External nostrils lateral. Palatal and splenial teeth with compressed crowns. Teeth equal, acute."

Isodectes megalops Cope.

Pariotichus megalops Cope, Proc. Am. Phil. Soc., vol. xx, 1883, p. 630.
Pariotichus megalops Cope, Trans. Am. Phil. Soc., vol. xvii, 1892, p. 25.
Isodectes megalops Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 442.

Type: Same as the genus.

Original description: "This reptile is known to me from a nearly complete, somewhat distorted cranium. A thin layer of matrix conceals the greater number

of the teeth, so that the presence of canines can not be demonstrated. Those which are visible are on the premaxillary and anterior parts of the maxillary bones. They are small, conic, slightly curved, acute, and absolutely smooth.

"The muzzle is short and broadly rounded. The narial opening is latero-superior, and is just above the principal convexity where the lores pass into the muzzle. Canthus rostralis rounded off. Interorbital region wide, convex in section, nearly plane antero-posteriorly, its width a little exceeding the diameter of the orbit. Orbit large and round, its diameter equal to the length of the muzzle in front of it, obliquely measured, and one half the distance from its posterior edge to that of the temporal roof (? squamosal bone). Posterior outline of the skull above truncate, surface slightly convex transversely.

"The premaxillary spines are short and wide, the nasals are also short and wide. The prefrontals and postfrontals form the superior edge of the orbit excluding the frontals. The intercalaria (or ? pterotics) are very large; at the externoposterior angle is a very small element in contact with the supraoccipital which may be the true intercalare. The supraoccipitals have considerable transverse extent, running out externally in narrow apices. All the bones of the skull are sculptured in honeycomb fashion, the ridges radiating on some of the bones—that is, on the posterior parts of the frontals and parietals and anterior part of the intercalare and squamosal. A groove follows the edge of the orbit and turns inward on the prefrontal bone, forming a rudimental lyra. External surfaces of the mandible grooved below; superior part concealed.

"*Measurements.*

	M
"Width of skull between posterior angles	0.018
Interorbital width	.008
Axial length of the skull	.024
Axial length from muzzle to between centres of orbits	.0096
Width of muzzle at nares	.0095
Length from orbit to nostril	.0035
Depth of skull posteriorly, to mandible	.010

"The superior part of the posterior region of the inner face of the dentary bone supports a patch of small obtuse teeth, which narrows forwards into the single row on the edge of the ramus."

Revised description of the genus and species:

1. Skull low and rounded anteriorly, amphibian in appearance.
2. Orbits large, located in the anterior half of the skull.
3. Teeth more sharply conical.
4. The teeth are missing in the position of the enlarged cheek tooth of other forms so that this character can not be made out.
5. Teeth in more than one row in the lower jaw; the maxillary series not visible.
6. Basioccipital and basisphenoid not visible.
7. Supraoccipital plates horizontal in the specimen.
8. Bones of skull with a fine radiating sculpture.
9, 10, 11. Not determinable.

The character of the sculpture, the position of the orbits, the minute size of the pineal foramen (none can be made out with certainty in the specimen), and the presence of a prominent coronoid process on the lower jaw, all indicate that this

specimen is entitled to consideration as a separate genus from *Pariotichus*. I can see, however, no warrant for the reference of the specimens from Linton, Ohio, to this genus. The figure published by Cope (**20**) showing the skull and lower jaw of the Linton specimen does not permit such a reference; the orbits are smaller, proportionately, and the lower jaw has not the prominent coronoid process. Only the anterior part of the body is shown and there is no warrant for connecting it with the specimen figured by Cope (**43**), Williston (**66**), and Moody (**51**) as *Isodectes copei* (*punctulatus*), in which only the posterior part of the body is preserved. Nor is there any certainty that either of them can be connected with the type skull.

Family CAPTORHINIDAE nov.

1. Small, but larger than the *Pariotichidæ*. Skull acuminate, rugose.
2. Basioccipital and basisphenoid small; not forming a plate on base of skull.
3. Incisor teeth much enlarged, tusk-like. Cheek teeth gradually increasing in size to the middle of the series and then decreasing, to the posterior end. More than one row in the jaws.

Other characters as given in the suborder.

Genus CAPTORHINUS Cope. (Plate 11, figs. 1, 2, 3.)

Captorhinus, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 443.
Pariotichus, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 443.

Captorhinus angusticeps Cope.

Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 443.

Type: An imperfect skull with both rami of the jaws in place. No. 4438 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description. Genus and species: "The head is wedge-shaped, with an acuminate and rather elongate muzzle. The orbits are round and rather large, the diameter being double the interorbital width, and equal to the length of the muzzle to the middle of the nostril. The teeth increase in length gradually from behind forwards, and the anterior mandibular teeth are inclined forwards at an angle of 45°. The premaxillary teeth have lost their crowns, but from the direction of the alveolæ, it appears that they were not directed posteriorly to any conspicuous degree. The posterior teeth of both jaws have obtuse crowns, and the crowns become more and more conic to the front. Nothing can be said of the character of the sculpture, as the surface of the bone, where present, is injured. The characters which distinguish the species as compared with other *Pariotichidæ*, besides those of the teeth, are the following: The interorbital width is less; the orbit large, entering the temporal length 1.5 times; and the skull is narrowed posteriorly, the width being three-quarters of the length, as in the *Pariotichus aguti*.

"*Measurements.*

	M
"Total length of the skull	0.062
Width of the skull posteriorly	.041
Interorbital width	.010
Diameter of the orbit	.016
Elevation of the crown of a posterior superior tooth	.0025
Elevation of the crown of an anterior superior tooth	.004
Length of posterior inferior tooth	.002
Length of anterior inferior tooth	.005
Depth of cranium at occiput	.014
Depth of mandibular ramus below temporal roof	.010"

In 1896 (41) there was given an extended account of the genus *Pariotichus*, but as this was based on *Captorhinus* (*P.*) *aguti* it may be taken as an account of Cope's observations on that genus:

"The maxillary teeth display the enlarged median tooth characteristic of the species referred to *Ectocynodon*, although it is less prominent than in some of the latter, and it is probable that the premaxillaries display corresponding enlargement. The type of *Ectocynodon* (*E. ordinatus* Cope) is in the same condition as regards teeth of the premaxillary series, but a long tooth is present near the mandibular symphysis, so that the characters are so far those of the other species referred to here. The elongation of the maxillary tooth is more conspicuous than in the *P. brachyops*. In general this tooth is not absolutely very large, but the teeth anterior and posterior to it are small or very small. Besides the usual series of teeth on the maxillary bone, there are two or more series adjacent. In like manner on the mandibular, besides the dentary series, there are two or three series, perhaps on the splenial bone, standing on a ledge on the same horizontal plane as the tooth-bearing edge of the dentary. In this genus, and probably in all the members of the family, the palate is roofed over posteriorly by the palatine bones. The pterygoids diverge early from the presphenoid region towards the zygomatic border, as in *Batrachia* generally. The mandibular articular surface consists of two cotyli placed transversely. The os tabulare is small, and is situated, as in other genera of the family, near the posterior junction of the supramastoid and supratemporal. The supraoccipital forms a narrow strip of the posterior border of the superior plane of the skull. The arrangement of the cranial bones is as I have described in the genera *Isodectes* and *Pantylus*, except that the prefrontal and postfrontal bones scarcely meet over the orbit, instead of separating the orbital border from the frontal. The occipital condyle, as in *Empedias*, is prominent, and has a median fossa.

"In *Pariotichus aguti* the vomers are elongate posteriorly and the palatines send an acute anterior process between them. The palatines are separated by a fissure which is narrow anteriorly and becomes wider posteriorly. Each interior border bears on its posterior two-thirds a row of small teeth. In this respect this genus differs from *Empedias*, where the palatines are closely appressed on the middle line. The suture between the palatines and the ectopterygoid is not easily made out, but this region descends below the maxillaries to opposite the middle of the inside of the mandible, as in many *Lacertilia*. Just anterior to the oblique angle which marks this descent a ridge of the palatines extends forwards and outwards, and for a short distance bears a row of teeth. These teeth, like those of the internal palatine series, are in a single row, differing in this respect from the species of *Pariasaurus*, as described by Seeley, where they are in two rows. The positions of the rows are the same in the two genera. The posterior border of the (?) ectopterygoid supports a patch of teeth in several rows. They are much less developed in *Pariasaurus*.

"The pterygoids are slender and diverge from the interior part of the palatines outward, backward and upward, to the inner side of the quadrate. They bear no teeth. The sphenoid is deeply grooved on the middle line, as in *Elginia*. Its lateral inferior keels project below the plane of the short basioccipital. There is no evidence that any of the rows of teeth of the upper jaw rise from the palatine bone; they appear to be maxillary in attachment.

"The specimen of *Pariotichus aguti*, on which the above observations are made, possesses, attached to the skull in nearly normal relations, seven vertebræ, a good deal of the scapular arch, and the right humerus. The fifth and sixth vertebræ have slender cervical ribs. The bodies of these, with that of the seventh, are the

only ones whose inferior surfaces are exposed. I observe narrow faces for intercentra between them. Of the scapular arch the clavicle and a median element are preserved. The former has a narrow subvertical portion which rests on the anterior edge of the scapula, and a horizontal portion which is considerably expanded, contracting gradually to the middle line. The median element is T-shaped, with the median portion or stem rather slender. It is broken off posteriorly, so that its apex can not be described. It underruns the expanded clavicles, and may be, therefore, supposed to be a cartilage bone and a true sternum, and not an interclavicle. A superficial layer of the exposed part of this element is roughened by sculpture, and probably represents the interclavicle. The inferior layer of the expanded part of the clavicle is similarly sculptured. The humerus has greatly expanded extremities and a slender shaft of moderate length. The form is similar to that of *Pariasaurus*. There is an angulation of the distal extremity which represents the condyle. Entepicondylar foramen well developed; no ectepicondylar foramen."

Revised description of the genus (based on all known specimens, as the type is in very poor condition):

1. Skull more elevated than *Pariotichus;* more acuminate.
2. Orbits large; in the posterior half or the middle of the skull; looking laterally.
3. Teeth obtusely conical or blunt.
4. Maxillary teeth increasing in size to the fourth or fifth and then diminishing. One or all of the incisor teeth enlarged.
5. Teeth in more than one row in the maxillaries and mandibles.
6. Basioccipital and basisphenoid not enlarged.
7. Supraoccipital plates vertical at the back of the skull.
8. Skull with a definite reticulate sculpture.
9. Scapula, coracoid, and procoracoid united.
10. Cleithrum absent.
11. Ischium and pubis broad and plate-like.

The following species of *Captorhinus* are considered as determinable: *aguti*, *angusticeps*, *isolomus*, and *aduncus*. No material illustrates better the difficulty of making species in vertebrate paleontology; each specimen might be considered as distinct and numerous species formed with characters given; or, with a little more freedom, all might be placed in a single species. The large number of specimens seem to fall into these four species and to be determinable with a fair degree of certainty.

Table showing the species of Captorhinus.

Smaller; median upper incisors larger than the others, they increase in size regular toward the median line. The third, fourth, and fifth maxillary teeth larger than the others . . . *aguti*

Larger; median upper incisors abruptly larger than the others and bent sharply backward. The fifth maxillary much larger than the others, the succeeding teeth much smaller than the preceding . . . . . *angusticeps*

Larger; resembles *angusticeps* but the skull proportionately wider behind. The proportions of the parietal bone different . . . . . *isolomus*

Smaller, size of *aguti*; median upper incisors abruptly larger than the second pair but not so much so as in *angusticeps*. Fifth maxillary larger than the first four, the sixth and seventh diminishing in size from the fifth but larger than the succeeding teeth . . . *aduncus*

Captorhinus aguti Cope.

Ectocynodon aguti Cope, Proc. Am. Phil. Soc., vol. xx, 1882, p. 451. (Also Pal. Bull. 35.)
Pariotichus aguti Cope, Am. Nat., vol. xxx, 1896, p. 301.
Pariotichus aguti Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, pp. 444 and 445.
Ectocynodon incisivus Cope, Trans. Am. Phil. Soc., vol. xvi, 1886, p. 290.
Pariotichus incisivus Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 445.

Type: A fragmentary skull showing the upper surface and the dentition of the upper jaw. No. 4344 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description of *Captorhinus aguti* (*Ectocynodon aguti*, 1882). No. 4333 Am. Mus. Nat. Hist. Cope Coll. From Texas.

"This reptile is much larger than the *P. brachyops*, and the anterior part of the cranium has a different form. The general shape of the head is much like that of a rodent mammal of the genus *Dasyprocta*. It is rather wide at the temporal regions, flat above, and narrowed and compressed anterior to the orbits. The muzzle is narrowed and obtuse, and the nostrils are terminal, and are lateral and a little anterior in direction. The maxillary alveolar edge is nearly straight, but the premaxillary edge, beginning below the posterior border of the nares, descends forward at an angle of 45°. Viewed from the front, the premaxillary border is a festoon, strongly convex downwards, and below the anterior part of the nostril. The suture separating the premaxillaries is distinct. The orbits are of moderate size, as in an aguti, and invade the superior frontal plane in a slight degree. The frontoparietal fontanelle is rather large.

"The mandible is robust, and presents a short angle. It closes up behind the premaxillary lobate edge. Its teeth are concealed in the specimen. The maxillary teeth increase rapidly in size forwards. The premaxillaries commence smaller next the maxillaries, and increase in size to the first, which is a little larger than the anterior maxillary. The crowns are weathered away. The sculpture on the maxillary and malar bones consist of closely placed shallow fossæ. On the posterior part of the frontals there are strong ridges radiating posteriorly, and situated close together.

"*Measurements.*

	M
"Length of the skull to the end of the angle of the lower jaw	0.090
Length of skull to frontoparietal fontanelle	.056
Length of skull to orbit above	.026
Lenth of ramus mandibuli	.082
Depth of skull at orbit	.033
Depth of ramus at orbit	.019
Width of skull posteriorly	.068
Width of skull between orbits	.017
Width of skull between external nares	.0105
Diameter of first premaxillary tooth	.003
Diameter of second maxillary tooth	.003
Six fossæ of the malar bone	.005
Seven grooves of the frontal bone	.005

"This species is much larger than the *Ectocynodon ordinatus* Cope, and the canine tooth has a much more anterior position."

Description of Ectocynodon incisivus, 1886: "The muzzle is quite prominent, a character somewhat exaggerated in the specimen by pressure. The nostrils are large, lateral in direction, and situated close to the end of the muzzle. The orbits are sub-round, of medium size, and look mainly upwards in the present condition of the specimen. One of the most important peculiarities of the species is the disproportionately large size of the first or anterior incisor or premaxillary tooth. The crown is conical and nearly straight, with an acute apex slightly posterior to the

central point. Its section at the base is slightly angulate. The two other premaxillary teeth are much smaller, the third quite minute and with a sharp apex.

"There are three maxillary teeth separated by rather wide interspaces, anterior to the large tooth, which gives character to the genus. The latter is abruptly large, but not equal in dimensions to the large first incisor. Posterior to it the maxillary teeth are closely placed, and with obtuse crowns. They commence very small, and increase in size posteriorly. At a point where the palatine or ectopterygoid, as the fact may be, joins the maxillary, the tooth-bearing surface is wide, and supports four rows of small, obtuse-crowned, spaced teeth of equal size. This dental patch is triangular, with its long angles extending anteriorly and posteriorly. The latter angle terminates a little posterior to the middle of the orbit. The teeth have a small axial pulp cavity, and the dentine is perfectly simple.

"The head sculpture is well defined, and is reticulated in pattern.

"*Measurements.*

	M
"Length from the end of muzzle to the posterior border of the orbit	0.054
Transverse diameter of the orbit	.016
Transverse diameter of interorbital space	.020
Length from the end of muzzle to the orbit	.034
Vertical diameter of nostril	.008
Vertical depth of maxillary in front	.013
Length of first premaxillary tooth	.0065
Transverse diameter of do	.0038
Distance between first incisor and large maxillary tooth	.013
Distance from large maxillary tooth to posterior angle of dental patch	.024
Width of dental patch	.0105
Elevation of a posterior tooth	.0015

"This species is intermediate in size between *E. ordinatus*, which is small, and the *E. aguti*, which is large. In its disproportionate inequality in size of the teeth, it differs from the latter; while the former has larger orbits and a different sculpture, besides having half the linear measurements. The sculpture of the *E. ordinatus* is in parallel ridges, inclosing minute punctiform pits between them."

Later, in 1896, Cope added to his original description:

"The long maxillary tooth nearer the nostril than the orbit. Sculpture reticulate. Interorbital and parietal sculpture reticulate; interorbital width 20 mm; interior jaw teeth with rounded crowns."

Revised description: Smaller. Median upper incisors not larger than the others; incisors increasing in size regularly toward the median line. The third, fourth, and fifth maxillary teeth larger than the others.

The specimen, No. 4333, called by Cope *Pariotichus* (*Ectocynodon*) *incisivus*, can not be distinguished from the one called *P. aguti*, No. 4344, and it seems advisable to unite the two under the earlier name. The type specimen of *aguti* has been deprived of the bone on the upper surface, so that the character of the sculpture can not be made out. The diameter of the orbit is given as about equal to the interorbital width; this is true of the horizontal diameter of the left orbit, but not of the right nor of the vertical diameter of either. Due to the crushing the specimen has suffered, the diameters are all notably different. The outlines of the skulls can not be compared, for the same reason, nor can the character of the posterior maxillary teeth, as they are not shown in *aguti*. On the other hand, both of these specimens have the median incisor greatly enlarged and the fourth or fifth maxillary tooth considerably enlarged. The two specimens have approximately the same size and proportions. These points connect the two specimens and separate them from all others.

Captorhinus isolomus Cope.

Pariotichus isolomus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, pp. 445, 446.
Pariotichus (?) *isolomus* Cope, Broili, Paleontographica, Band LI, 1904, p. 86.
Pariotichus laticeps Williston, Journ. Geology, vol. XVII, No. 3, August 1909, p. 241.

Type: Complete skull. No. 4338 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "This species is most nearly allied to the *P. aguti*. The form of the skull is different and also the sculpture. The skull is equilateral, and the posterior superior border is nearly straight. The muzzle projects beyond the mouth border, so that the incisor teeth are directed backwards at an angle of 45°. The nares are separated by a space equal to their long diameter. The orbit is of moderate size. Its anterposterior diameter enters the lengths of the skull anterior and posterior to it 1.75 times, being midway of the total length. It exceeds by a little the interorbital width. The mandibular ramus is robust, being a little deeper than wide, and the angle is small and pinched, projecting behind the articulation and in line with the rising inferior border. The parietal foramen is well developed.

"In the sculpture of the superior surface of the skull the longitudinal striæ are more prominent than the transverse ones which connect them, except on the muzzle, where they are about equally conspicuous. The sculpture is finer and reticulate on the jugal and quadrato-jugal regions. About a dozen longitudinal ridges between the orbits. Sculpture of the mandible tubercular reticulate.

"Three teeth on each premaxillary bone, of graded lengths, the anterior being much the larger. Posterior to these one or even two smaller teeth may stand on the premaxillary. The large tooth of the maxillary is the third from the premaxillary suture. At the fifth tooth the second longitudinal row appears, and at the eighth tooth, the third. There are ten teeth in line with the row which is external anteriorly, but posteriorly a short row appears external to this one, which includes five teeth. The crowns of the teeth of the two internal rows are low and compressed, so as to have a longitudinal edge. In the lower jaw there are three rows with compressed crowns besides the external row. Posteriorly the marginal and the third row (from without) disappear, and the second and fourth approximate and end in a single tooth in line with the second row.

"In one of the specimens the cranial roof posterior to the orbit can be lifted off. Above the sphenoid region, viewed from above, there are four subround tuberosities, which look like the casts of cavities. On the inferior side of the roof in the corresponding positions are four flat tuberosities, of somewhat different form from the inferior ones, and an obtuse median prominence, which fits into the space between the four inferior tuberosities. These superior tuberosities resemble the casts of cavities left by the dissolution of two hemispheres, and two transversely expanded larger, mesencephalic lobes, with a hypophysis between them. This interpretation is, however, very uncertain, especially as the structure does not resemble the cast of the cranial cavity, which I have previously described in *Empedias*.

"*Measurements.*	M
"Length of the cranium on the middle line	0.076
Width of the cranium posteriorly	.063
Anteroposterior diameter of the orbit	.016
Interorbital width	.013
Width between nares at front of muzzle	.009
Diameter of largest maxillary tooth	.0025
Length of long premaxillary tooth	.007
Diameters of mandibular ramus at fourth tooth:	
Vertical	.0105
Transverse	.009"

Abstract of Broili's analysis of P. isolomus:

Skull triangular. Orbits large and round. Nares terminal and round. Parietal foramen present. Sculpture formed largely of more elongate lines; on the sides the presence of cross lines produced a pretty regular network. Parietal bordered in front by the frontal, postfrontal, and postorbital. The frontal takes small part in the border of the orbits. The pterygoid is tripartite, the anterior portion bears small teeth and the inner edges of the two bones are united anteriorly; posteriorly the edges are separate and between them can be seen the slender parasphenoid rostrum. The posterior portion is extended as a broad plate back to the quadrate. The third (ectopterygoid) portion is truly only a thickening of the posterior border of the anterior portion, but may be spoken of as true process because it is sharply offset from the anterior portion behind, though it joins it gradually in front; the teeth on the process in this specimen are destroyed. The jaw teeth are obscured by the fact that the lower jaws are in position, but there are two or three rows of teeth on the maxillary.

Measurements.

	M
Total length of the skull in the middle line	0.045
Breadth of the skull, posterior edge	.027
Distance posterior edge of the nares to the anterior edge of orbit	.010
Distance between nares	.0035
Distance from orbits to posterior edge of skull	.016
Distance between orbits	.0085
Anteroposterior diameter of orbits	.0145
Transverse diameter of orbits	.0125

Revised description: This species resembles *C. aguti* in most particulars, but the skull is wider and lower in proportion to the length. The difference was at first thought to be due to crushing, especially as the skull of *aguti* is somewhat compressed from side to side, but there is also a notable difference in the proportions of the parietal bone. In skulls of nearly the same length the parietal measures 17.5 mm. in *C. angusticeps*, No. 4334 Am. Mus. Nat. Hist. Cope Coll., and 24 mm. in *C. isolomus*, No. 4338 Am. Mus. Nat. Hist. Cope Coll.

Captorhinus aduncus Cope.

Pariotichus aduncus Cope, Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 135.

Type: An imperfect skull and a few fragments of the skeleton. No. 4332 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The species is intermediate in size and characters between the type of the genus *P. brachyops* and the larger *P. aguti*, besides presenting a number of peculiarities of its own. The elongate maxillary teeth are graded in size to the smaller; and the sixteenth from behind, the largest, is nearer the anterior border of the orbit than to the nostril. In front of it are three teeth which are preceded by an interval. There are three and perhaps four incisors on each side, of which the external two are small and the internal two very large, the inner the largest. The mandibular teeth increase regularly in length anteriorly. The nostrils are lateral and absolutely terminal. The premaxillary bones are recurved so that the alveolar edge is in vertical line with the posterior border of the nostril. Thus this recurvature exceeds that seen in any other species of the genus, and the symphysis mandibuli is correspondingly posterior. The orbits are larger than in any other species, exceeding the interorbital width considerably, and equaling the length of the muzzle from the orbit to the middle of the nostril. The muzzle is

wide above in proportion to its length. It is probable that the width of the skull behind does not exceed the length from the posterior border to the front of the orbit, though this measurement is uncertain, owing to the mutilated condition of the right side.

"The surface is sculptured with shallow pits separated by rather thick ridges. The nasal bones send back a short angle of the external margin to meet the inferior prefrontal suture, about half-way between the orbit and the nostril.

"*Measurements.*

	M
"Length of skull to the end of os quadratum	0.054
Length of skull posterior to orbit	.018
Length of orbit	.015
Length from orbit to nostril	.012
Width of muzzle at middle	.105
Width of the interorbital space	.010
Width of the internarial space	.008
Length of the recurved part of the premaxillary	.007
Length of premaxillary I, 1	.005
Length of the longest premaxillary tooth	.004
Depth of mandible at middle of orbit	.006"

Revised description: The median pair of upper incisors are abruptly larger than the second, but not so much so as in *aguti*. The fifth maxillary tooth is abruptly larger than those before it, the sixth and seventh smaller than the fifth but larger than those which follow. The position of the premaxillary bones and the lower jaw in the type specimen is evidently due to crushing which pushed the lower part of the skull backward with reference to the upper. The sculpture of the surface is not to be distinguished from that of the other species. The proportions of the skull and the orbits are not to be trusted as they would be in recent skulls, for all have suffered more or less from crushing and every specimen would show variations in the diameters of the orbits, the interorbital width, and length of the skull. The three mandibular incisors are enlarged, as in all the species.

Genus LABIDOSAURUS Cope. (Plate 12.)

Pariotichus Cope, Proc. Am. Phil. Soc., vol. xxxiv, 1896, p. 448.
Labidosaurus Cope, Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 136.
Pariotichus Case, Zoolog. Bull. vol. ii, 1899, p. 231.
Labidosaurus Broili, Paleontographica, Bd. ii, 1904, p. 51.
Labidosaurus Williston, Jnl. Geol., vol. xvi, 1908, p. 395.

Type: A skull with the lower jaw. No. 4341 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "One series of pleurodont maxillary teeth slightly unequal in size. Internal incisor much enlarged, conic, acute, and directed backwards. No teeth on the maxillopalatines; teeth on the palatines small, subconic, in one row. Nostrils lateral. Better specimens of the above species (*P. hamatus*) show that it has but one row of maxillary teeth, which are pleurodont, so that it is clearly a member of a genus distinct from *Pariotichus*. If the character which I have assigned as definitive of the *Pariotichidæ* be the true one, the genus *Labidosaurus* must be referred to a different one, and I know of no character at present to separate it from the *Pariasauridæ* of which the known species are, so far as known up to the present time, restricted to South Africa. It differs from the known genera of that family in the greatly elongate premaxillary teeth, and in the simple conic dental crowns."

Revised description:

1. At least twice the size of *Captorhinus*. Skull acuminate anteriorly, very wide posteriorly.
2. Orbits of moderate size, located near middle of the skull.
3. Teeth obtusely conical.
4. Maxillary teeth not greatly different in size. Median incisors much larger than others and bent sharply backward.
5. Teeth in more than one row on maxillary and mandible (*fide* Williston).*
6. Basioccipital and basisphenoid not large.
7. Supraoccipital plates vertical at the back of the skull.
8. Skull with reticulate sculpture.
9. Scapula, coracoid, and procoracoid united.
10. Cleithrum absent.
11. Ischium and pubis broad and plate-like.

Labidosaurus hamatus Cope.

Pariotichus hamatus Cope, Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 445, 448.
Labidosaurus hamatus Cope, Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 136.
Pariotichus incisivus Case, Zool. Bull., vol. II, 1899, p. 231.
Labidosaurus incisivus Williston, Journ. Geol. vol. XVI, 1908, p. 359.

Type: Same as that of the genus.

Original description: "Besides exceeding in size the other species, this one is characterized by the elongation and compression of the muzzle, and by the extent of the projection of the premaxillary region beyond and below the mandibular rami.

"The length of the skull a little exceeds its posterior width. The lateral outlines expand rapidly from the anterior borders of the orbits, posteriorly, while from this point anteriorly the lateral outlines of the muzzle converge very gradually. The transverse section of the muzzle is subrectangular, and not a segment of a circle as in other species, the superior face being nearly flat and the maxillary borders somewhat contracted. This form may, however, be due to pressure. Opposite the posterior border of the nostril the premaxillary bone is steeply decurved, forming a concavity which receives the extremity of the mandible. The deflected portion of the premaxillary forms a lobe which projects as far as the continuation of the line of the inferior border of the ramus mandibuli. An open emargination of the border separates it from the corresponding lobe of the opposite side. This may be due to accident. The mandible is narrower than the muzzle at the symphysis; it is a little wider than the cranium at the front of the orbit, but it is narrower than the cranium posterior to it.

"The orbit has an oval outline, with the long axis anteroposterior, which enters the length of the cranium posterior to it twice, and one-and-three-quarters times the length anterior to it, and a little exceeds the interorbital width. The latter is flat. The posterior outline of the skull forms a wide open emargination. The surface of the skull and jaws is so much injured in both specimens as to render it impossible to state the character of the sculpture, if any existed.

"The teeth are not well preserved, although where preserved their length can be determined in the limestone matrix. The elongate maxillary tooth is placed exactly half-way between the borders of the orbit and the nostril, which is posterior to its position in the *P. aguti*. The other maxillary teeth are small in comparison

* In a paper published since the preparation of this manuscript Branson, Journal of Geology, vol. XII, No. 2, pp. 135–139, reports the presence of more than one row of teeth in the jaw of *Labidosaurus;* observed in two specimens.

with the size of the skull. The enlarged anterior premaxillary teeth are not well preserved, and their size is uncertain. In some other specimens of similar size with rounded cross section of the muzzle, these teeth are enlarged as in *P. aguti*.

"*Measurements.*	M
"Length of cranium from line connection posterior borders of quadrates	0.162
Length of cranium from middle of posterior border	.145
Interorbital width	.032
Diameters of orbit:	
Anteroposterior	.036
Vertical	.022
Width of muzzle at posterior border of the nares	.029
Depth of muzzle at posterior border of the nares	.021
Depth of the cranium at middle of the orbit	.035
Length of crown of large maxillary tooth	.006
Depth of mandible at middle of orbit	.020
Length of mandible on ramus	.170"

On page 445 of the same article Cope gives an analytical table of species in which *L.* (*P.*) *hamatus* is described as follows:

"Orbit oval; cranium 162 mm. long, and nearly as wide; posterior border emarginate; muzzle much contracted, entirely overhanging symphysis mandibuli."

Later, in referring the species to the genus *Labidosaurus*, Cope added the following specific description:

"Specimens since received display numerous characteristic peculiarities not preserved in the type. The sculpture of the cranial surface is in shallow fossæ with rather thick partitions, of smaller size than in the *Pariotichus aguti*, which resembles it most nearly. Thus there are a dozen ridges between the orbits on the frontal in the latter, while there are fifteen to seventeen in the *L. hamatus*. The maxillary teeth are relatively smaller than in any of the species of *Pariotichus* known, and they extend only to below the middle of the orbit. The orbit is subround; in the type it is oval, perhaps owing to pressure. Its diameter is about half the length of the skull, both anterior and posterior to it, and equals the interorbital width. The nostril is anteroposteriorly oval, and the apex of the elongate incisor tooth is below its anterior part. Thus, though the muzzle is more elongate than in any of the species of *Pariotichus*, it does not project so far beyond the premaxillary border. Length of the skull of the new specimen 155 mm."

Revised description: The original description is adequate and correct. This species differs from the following by the possession of but a single pair of enlarged incisors in the premaxillaries instead of two pairs.

Labidosaurus broilii sp. nov.

Labidosaurus hamatus Broili, Paleontographica, Bd. II, 1904, p. 51.

This species resembles *L. hamatus* in most regards, but differs in the possession of two enlarged incisors in the upper jaw instead of a single pair. Differences in the skeleton are unknown.

Hyponous squaliceps Cope.

Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 450, figs. 3-5, pl. VIII.

Type: Two skulls. No. 4335 Am. Mus. Nat. Hist. Cope Coll. From Texas.

This genus was founded on a curious misunderstanding of the specimen by Cope. His original description of the genus reads as follows: "Nostrils on the inferior aspect of the muzzle. Teeth few, with compressed crowns. Cranial

bones sculptured. Frontal bone bounding the orbit above. This genus displays in this family the character found in *Lepidosternum* and other genera among the *Amphisbænidæ*. The large superiorly placed orbits and inferior posterior mouth indicate that the animal lived in some locality where upward vision was important, while its food was below it."

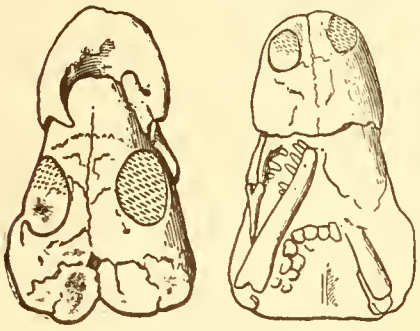


FIG. 11.—Two views of the two specimens called *Hypopnous squaliceps* by Cope. × ⅔. No. 4335 Am. Mus.

A glance at the specimen (see fig. 11) shows that there are really two skulls present. The larger one is probably a species of *Captorhinus* and the smaller, which is held in the mouth of the larger, is that of a small amphibian. The small skull is inverted so that the orbits, which Cope described as the large inferior nares, lie on the lower side of the larger skull. The apparent shortness of the lower jaws of the larger skull is due to their having been shoved backward by crushing.

The genus and species must be dropped.

Genus HELODECTES Cope.

Proc. Am. Phil. Soc., vol. XIX, 1880, pp. 45 and 48.
Proc. Am. Phil. Soc., vol. XXXV, 1896, p. 442.

Type: A left maxillary and probably premaxillary bone. No. 4346 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: In 1880, p. 45, Cope distinguishes the genus *Helodectes* from *Diadectes* and *Empedocles* by the presence of two rows of molar teeth. On page 48 of the same article he states that the characters are in general the same as those of the family *Diadectidæ*. He adds that there is apparently a large tooth in the position of an anterior incisor in the typical species. In 1896 he states that the genus probably belongs to the family *Pariotichidæ*.

Revised description: The material upon which this genus is based is so imperfect as to make it very doubtful if a second specimen could be determined with confidence. The numerous teeth in the fragment of the jaw indicate a member of the suborder *Pareiasauria*, but the fragment and the roots of the teeth indicate an animal much larger than any well-known member of the suborder. The genus is retained provisionally.

Helodectes isaaci Cope.

Proc. Am. Phil. Soc., vol. XIX, 1880, p. 49.

Type: A fragment, probably of a maxillary bone, lacking both ends and considerably obscured by matrix. From Texas.

Original description: "The bases of the teeth of one of the rows are much more expanded transversely than those of the other, having the form of some of those of *Empedocles*. As in that genus, they shorten anteriorly. In the fragment I count, on this row, bases of nine teeth. In the other row I can only definitely count three, which are opposite the second, third, and fourth of the other series (counting from behind). They are wide transverse ovals, about half the long diameter of the posterior teeth of the other series.

"*Measurements.*

	M
"Length of bases of eight larger molars	0.032
Diameter of large molar:	
Anteroposterior	.004
Transverse	.008
Length of three smaller molars	.012
Long diameter of a smaller molar	.004"

The type and only specimen of this species is lost and no specimen can be identified from Cope's description.

Helodectes paridens Cope.

Proc. Am. Phil. Soc., vol. xix, 1880, p. 48.

Type: The same as the genus.
Original description:

"Molar teeth of the two rows subequal in size, and equally numerous . . . . *H. paridens.*
Molar teeth of one row wider, and more numerous than those of the other. . . *H. isaaci.*

"The smallest species of the family is about half the size of the *Empedocles molaris.* It is represented by a left maxillary and probably premaxillary bone, which are so far covered with the adhesive, hardened ferruginous mud of the formation as not to expose a clean surface. The apices of all the teeth are broken off, so that the bases alone remain to indicate their number, form, and positions.

"Of the molar teeth proper, I count six in the inner and eight in the external row. The two series are close together, and are gently convex inwards. The bases of the teeth are wide ovals, transversely placed. In front of the eighth tooth of the external row (from behind), are two teeth without apparent mates of the internal row (possibly the latter lost). Then follows a tooth of each row, and in front of these another pair, the external being the larger. Anterior to these, the jaw is so split as to remove any teeth of the inner row, if there are any, and one large tooth of the external series stands in the extremity of the fragment. This latter exceeds the other teeth in the length and diameter of its basal portion. From its position it is probably an incisor.

Fig. 12.—Fragment of jaw of *H. paridens.* × ¾. Type No. 4346 Am. Mus.

"The anterior border of the orbit falls above the third tooth of the external row (counting from behind). The inner border of the maxillary bone is elevated into the ridge convex inwards, as in the other species of this family. The malar base of the zygomatic arch is a moderately stout vertical oval.

"*Measurements.*

	M
"Length of the dental series	0.062
Length of the molar 6-8 series	.029
Width of the two molar series	.009
Vertical diameter malar bone	.013"

Revised description: It is impossible to determine whether the fragment is that of a maxillary bone or a part of the lower jaw. The condition is best shown by the figure. A large part of a skeleton, or of several skeletons doubtfully associated with the jaw fragment, seemingly belongs to some Diadectid animal.

Family SEYMOURIDAE Williston.

Jnl. Geol., vol. XIX, 1911, p. 237; Science, vol. XXXIII, 1911, p. 851.

1. Skull size of *Labidosaurus*. A large epiotic notch, quadrate exposed but without posterior hook. Surface of skull rugose.
2. Median incisors not enlarged. Cheek teeth simple cones, none enlarged.
3. Teeth in a single row (?).
4. An intertemporale present.

The skull of *Conodectes* is in a very poor state of preservation and is largely restored in plaster. The general form of the skull is amphibian and the otic region is excavated to show the quadrate. The notch which reveals the quadrate is elongate and the anterior end is continued downward and inward as a deep pit or notch. There is a single row of bluntly conical teeth in both jaws; the broken bases do not show any radial arrangement of the dentine. The palatines and the pterygoids are broad plates, the latter bones nearly meeting in the median line. Both palatines and pterygoids are devoid of teeth.

The nature of this animal is very uncertain, but it certainly is very different from the *Diadectosauria*. It might be considered as an amphibian, were it not for the condition of the pterygoids. The nearest form to *Conodectes* is *Seymouria* Broili, and I propose to unite them in the family *Seymouridæ* to replace the family *Otocœlidæ* eliminated by the removal of *Otocœlus* to the Amphibia.*

Genus SEYMOURIA Broili. (Plate 13.)

Seymouria baylorensis Broili.

Paleontographica., Bd. LI, 1894, p. 82.
Anat. Anzeig., Bd. XXV, 1904, p. 37.

Type: Two incomplete skulls in which the anterior end of the snout is wanting. One has the pectoral girdle and a few vertebræ. Nos. 17 and 18, XV, 1901, Mus. Alte Akademie, Munich. From West Coffee Creek, Willbarger County, Texas.

Original description: "Contour of the skull triangular. Auditory notches present. Upper surface nearly flat, but the sides and the occipital region steeply inclined. Orbits lateral, large and circular, more in the posterior than in the anterior half of the skull. Parietal foramen present. Surface with a rough radiating sculpture which sometimes ceases at the border of a bone and sometimes passes over to the next one. The supraoccipital and tabulare form a small crescentic plate, which is sharply set off from the upper portion of the skull and is inclined steeply to the rear. The parietal is large and broad. The nares are only partly preserved. Orbital ring formed by the postorbital, prefrontal, postfrontal, lachrymal, and jugal. Auditory notch formed by the tabulare, squamosal, prosquamosal, and quadratojugal. An intertemporal bone present. The maxillary begins directly under the eye, and the largest tooth (so far as the imperfect dentition shows), is rather far forward. The basioccipital is but little exposed and carries a well-formed, slightly concave occipital condyle. The basisphenoid is flat on the median line and the sides are elevated into keel-like processes. Parasphenoid rostrum present. The pterygoids do not meet in the median line posteriorly, but come together at the anterior portion. The external process of the pterygoid, which borders on the palatal vacuity, does not show the strong swelling that appears in *Captorhinus*

* The name *Seymouridae* was published by Williston, after this article was in proof, as he was unaware that I had used it in the manuscript.—E. C. C.

aguti, but there is a slighter development of the same thing. The posterior portion of the pterygoid takes part in the border of the palatal vacuity, forms a part of the border of the auditory notch, and aids in the closure of the posterior portion of the skull. Numerous small teeth are found on the anterior process of the pterygoid and on the external process.

"The foramen magnum is bordered by four bones: (1) Exoccipital; (2 and 3) the inner branches of the exoccipitals which expand broadly and unite above with the (4) supraoccipital. The outer branches of the exoccipitals bend first outward and then upward to the tabulare, inclosing a foramen between them and the tabulare. Above the foramen the border line between the two inner branches of the exoccipital are not so clear; it almost seems as if they inclosed between them and the supraoccipital another foramen. The lower jaws are closely pressed against the skull in both specimens. No observations can be made on the teeth.

"*Measurements of skull.*

	cm
"Breadth of the skull on the posterior border	10.5
Total length in the mid (so far as preserved)	10.2
Separation of the orbit from the posterior border of the skull (auditory notch)	1.8
Distance between orbits	3.1
Length of orbit	ca.2.7
Breadth of orbit	ca.2.6

"*Pectoral Girdle:* The interclavicle is rhombic anteriorly with a long posterior process. The anterior end has a rough radiate sculpture. The clavicles are wing-like, the posterior end bends backwards and upwards in an obtuse angle to form spatulate process so that they covered in this way the sides of the animal. The proximal ends do not meet in the median line and are covered with rough sculpture. There is no evidence of a cleithrum; the condition of the specimens does not permit a final conclusion as to its presence. The vertebræ shown have low transverse process, the neural arch is saddle-shaped and broader than long. The pre- and post-zygapophyses are horizontal. The ribs are double headed (?) and the distal end is expanded and shovel-shaped."

Revised description of the genus and species:

1. The skull a little broader than long; blunt anteriorly.
2. Orbits large, more in the posterior half of the skull than in the middle, looking laterally.
3. Not determinable.
4. Not determinable.
5. Not determinable.
6. Basioccipital and basisphenoid not large.
7. Supraoccipital plates, nearly vertical but occupying a considerable space, are on the upper surface of the skull.
8. Skull with definite reticulate sculpture.
9. Not determinable.
10. Cleithrum absent.
11. Not determinable.

This genus was reported by Broili to have both prosquamosal, squamosal, and quadratojugal bones, but a reexamination of the specimen by Dr. Broili and the author shows that there are but two bones on the side of the skull, as in the *Pariotichidæ* and *Captorhinidæ*. The presence of an intertemporal bone justifies its separation as a distinct family. (See also Williston, Journal of Geology, vol. XIX, p. 232.)

Genus CONODECTES Cope.

Cope, Am. Nat., vol. xxx, 1896, p. 398.
Cope, Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 129.

Type: An imperfect skull. No. 4342 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: In the "American Naturalist" for 1896 Cope gave an analysis of the family *Otocœlidæ:* "Cranial roof excavated laterally behind, forming a large meatus auditorius. Teeth present in a single row, not transversely expanded. Suspensorium directed posteriorly; nostrils vertical."

In the "Proceedings of the American Philosophical Society" he writes:

"Quadrate bone extending posteriorly so that the mandibular articulation is opposite the posterior border of the cranial table. Meatus auditorius small, connected with the meatal notch. Nostrils directed upwards and a little outwards. Teeth conic, acute, increasing in size to the middle of the maxillary region."

Conodectes favosus Cope.

Proc. Am. Phil. Soc., vol. xxxv, 1896, p. 129.

Original description: "The teeth preserved show that the premaxillary teeth are small, as in the *Isodectes megalops*, and that they increase in length posteriorly. The maxillopalatines are excavated on the median line, so as to present two parallel ridges which continue as far as the posterior border of the internal nares. These ridges probably continue on a palatine bone and they support each a tooth near the posterior extremity. In *Isodectes megalops* the palatines support numerous small teeth on their inner borders. I find no trace of the interior rows of maxillary and mandibular teeth which are characteristic of the *Pariotichidæ*. Some such teeth may, however, have existed, as a portion of the maxillary bone is wanting from both sides of the skull.

"This species is seven or eight times the linear dimensions of the *Isodectes megalops*, and a little smaller than the *Otocœlous testudineus*. The skull is as wide posteriorly as it is long, and is rather depressed, so that the orbits and nares have a vertical as well as a lateral presentation. The muzzle is flat and projects beyond the lower jaw, and it is rounded in outline, and not narrowed and protuberant as in most of the species of *Pariotichus*. The internareal and interorbital regions are flat. The narrower brain case is continued between the orbits, and its lateral walls are robust. The palatine bones extend from the maxillaries, and approximate each other nearly on the median line, where they are separated medially by a groove, which becomes wider posteriorly. No teeth can be discerned in the specimen, excepting the large anterior one already mentioned. The surface of the bone is, however, not in good condition. The plate of the pterygoid extends to the jugal on each side, and its posterior border is but little deflected, and is at right angles to the long axis of the skull with indications of teeth. The posterior branch of the pterygoid is slender. The occipital region is injured. The superior surface of the skull is sculptured, on the posterior frontal region in a coarse honeycomb pattern, the ridges occasionally forming small tubercles.

"The teeth are conic, acute, and with a round section. In this respect they differ from those of most of the species of *Pariotichus*, where the crowns are obtuse. They are rather closely placed, and they increase in length to below the anterior border of the orbit. Their character posterior to this point can not be ascertained. The single, large palatine tooth is similar to the maxillaries in form, and equals in dimensions the maxillary tooth which is below the posterior border of the nostril.

The posterior border of the internal nostril marks a point half-way between the posterior border of the anterior nostril and the anterior border of the orbit.

"*Measurements.*	mm
"Total length of skull	158
Width posteriorly	152
Width between nostrils	20
Length from end of muzzle to posterior border of pterygoid plate	103
Width between summits of ridges of vomer	10
Length from posterior border of nostril to anterior border of orbit	41
Length of longest maxillary tooth	10
Diameter of longest maxillary tooth at base	3·5"

Revised description: The original description is correct except with regard to the palate. The paired prevomers are plate-like and close the anterior portion of the palate; following these are distinct palatine and pterygoid bones, the latter coming close together in the median line. *Conodectes* may, as suggested by Williston, be identical with *Seymouria*.

FOREIGN FORMS.

Genus PAREIASAURUS Owen.

Owen, Cat. Foss. Rep. South Africa, 1876, p. 9.
Seeley, Phil. Trans. Roy. Soc., 1888, p. 75.
Broom, Annals South African Museum, vol. IV, 1903, p. 123.
Bull. Am. Mus. Nat. History, vol. XXVIII, art. XX, 1910, p. 201.

Broom in his last paper gives the following summary of *Pareiasaurus:*

"Though four fairly good skeletons of *Pareiasaurus* have been discovered which reveal most of the general structure of the skeleton there are many details of which we are still ignorant.

"The skull is large with the temporal fossæ completely roofed over, but the detailed structure of the roof is still doubtful. There appears, however, to be little

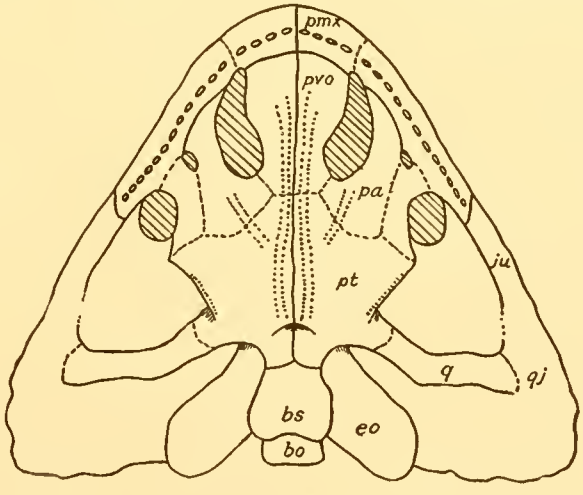


FIG. 13—Palate of *Pareiasaurus*. After Broom. Slightly restored.

doubt that there is a quadratojugal. The bones are pitted somewhat like those of Stegocephalians. There is a distinct septomaxillary. The palate is fairly well known and, as shown in the figure (fig. 13), has the typical structure met with in most primitive reptiles. There are paired prevomers bearing teeth, paired palatines

probably also bearing teeth, and apparently small transpalatines. The pterygoids are fairly large and have rows of small teeth.

"The occipital condyle is flat.

"The vertebræ are large and massive and have intercentra. The zygapophyses are very broad. The ribs for the most part are single-headed.

"The shoulder girdle has a large scapula with a well-developed acromion, large precoracoid and fairly large coracoid. There is well-developed cleithrum, fairly large clavicles, and a massive T-shaped interclavicle.

"The humerus is very massive and has a large deltopectoral ridge. The ulna has an olecranon process.

"The carpus, so far as known, appears to be similar to that of most early reptiles.

"The digital formula is unknown. It has been stated to be 2, 3, 3, 4, 3, but in the closely allied *Propappus* it is most probably 2, 3, 4, 5, 3, two digits having certainly more than 3 phalanges.

"There are apparently no abdominal ribs.

"The pelvis is remarkable for having the ilium large and directed forward as in Mammals and the higher Therapsida.

"The teeth are pecularily specialized. Externally they are markedly convex, the inner side being nearly flat. Round the edges are 7 or 9 large cusps arranged in a semicircle."

Genus ANTHODON Owen.

Owen, Cat. Foss. Rep. South Africa, 1876, p. 14.

Imperfectly known. Skull more vaulted than in *Pareiasaurus*. Teeth with short, compressed, and anteroposteriorly expanded crowns, having a convex, subtrenchant free edge, marked by numerous crenulations, roots long and narrower than the crowns. Centra of the dorsal vertebræ with deeply cupped terminal faces, and no evidence of the presence of intercentra.

Genus PROPAPPUS Seeley.

Seeley, Proc. Roy. Soc., vol. XLIV, No. 267, 1890.
Broom, Annals of the South African Museum, vol. IV, pt. VIII, 1890, p. 351.

Type: A humerus. No. 36250 in the British Museum.

Homotype: The "greater part of a large skeleton," now in the South African Museum. Described by Broom.

Description of the homotype: Skull represented by fragments of a maxilla and the mandibles. Mandibles with two projections from the lower edge, instead of one as in *Pareiasaurus*. The crowns of the teeth flattened, semicircular, with eleven cusps on the maxillary teeth; cusps on the mandibular teeth similar to those on the maxillary but smaller. Vertebræ as in *Pareiasaurus*, the centrum rather slender and elongate; biconcave but not deeply excavated. Intercentra present. Transverse process broad and powerful, spine low and short. Limb bones and girdles differing little from *Pareiasaurus*. Tarsus with a single proximal element; distal tarsals probably small and largely cartilaginous. Foot broad and short, digital formula almost certainly 2, 3, 4, 5, 4, certainly more than 2, 3, 3, 4, 3. "Whole back and probably sides covered with a carapace of bony plates somewhat after the manner of a crocodile." There is no evidence of any plastron.

Genus ELGINIA Newton.

Trans. Roy. Phil. Soc., vol. 184, pp. 431-503.

Type: The cast of a skull from the Elgin Sandstone. Preserved in the Museum of Practical Geology, London.

This genus is known only from the cast of a cavity in the sandstone and so only the external form can be made out. It is evidently closely related to *Pareiasaurus*, but has numerous prominent spines on the posterior edge of the skull, resembling in this regard the Pareiasaurians from Northern Russia.

Genus SCLEROSAURUS H. v. Meyer.

Sclerosaurus H. v. Meyer, Paleontographica, Bd. VII, pp. 35-40, Taf. 6.
Labyrinthodon Wiedersheim, Abh. Schweiz. pal. Gesell. Bd. 5.
Aristodesmus Seeley, Proc. Roy. Soc., vol. 59, pp. 167-169.
Aristodesmus Seeley, Quart. Journ. Geol. Soc., vol. 56, pp. 620-645.
Sclerosaurus v. Huene, Geol. u. pal. Abhmdlg. n. b., Bd. VI, Heft 1.

The specimen was found in the Buntersandstein near Rheinfelden.

Skull completely roofed over and the posterior bones carrying prominent spines, especially the squamosal, quadrate, and quadratojugal. Skull flatter than that of *Elginia*. Occipital condyle hemispherical, as in *Pareiasaurus* and *Elginia*. Von Huene figures large palatal vacuities in his reconstruction of the palate, but there seems no warrant for this in the specimen or from analogy with other Pareiasaurians. External nares, terminal and vertical. Seven blunt conical teeth preserved in the maxillary and four rather sharper ones in the premaxillary, but it is not certain that

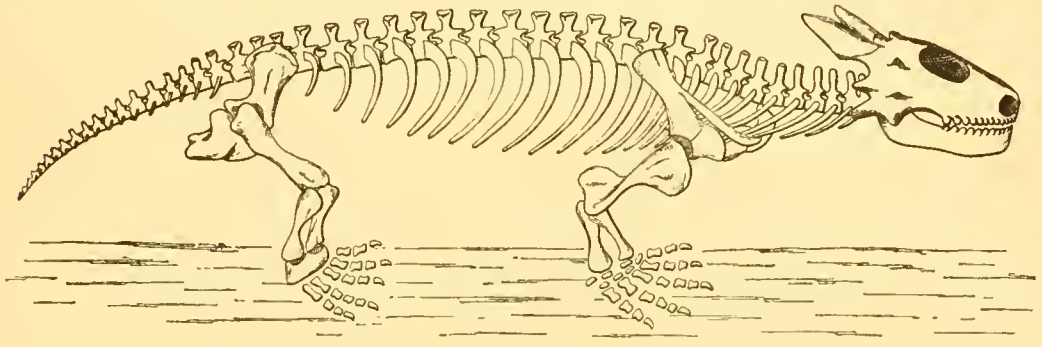


FIG. 14.—Outline reconstruction of *Sclerosaurus*. After von Huene.

this is the complete number. Surface of the skull smooth with the exception of the projections at the back of the skull. Seeley and Wiedersheim report twenty-two presacral vertebræ, v. Huene twenty-one. Vertebræ notochordal and shorter on the lower line than the upper, leaving spaces for intercentra; a sharp keel on the lower surface of the centrum gives it a triangular section. Neural spines short, with the upper ends expanded and rugose where they came in contact with the dorsal plates. Transverse processes strong and heavy with single articular faces for the single-headed rib. Three sacral vertebræ, the ribs of the anterior and posterior being larger than the middle one. Shoulder girdle with free scapula, coracoid and precoracoid, cleithrum probably present. Carpus with two rows of bones, a proximal, consisting of radiale and ulnare, and a distal with four elements. In the pelvis the pubis and ischium meet each other at an angle and resemble more the same bones in *Pareiasaurus* than in the *Diadectidæ* and *Captorhinidæ;* the ilium resembles that of *Dicynodon*. Astragalus and calcaneum united in a single large element, the distal row not ossified. Dorsal armor consisting of six rows, the inner two rows lying on either side of the neural spine and overlapping the postzygapophyses; each with a dorsal keel and a pitted sculpture. Outer rows of smaller irregular plates.

Genus PHANEROSAURUS H. v. Meyer.

Phanerosaurus naumanni, Paleontographica, 1860, Bd. VII, pp. 248-252, Taf. XXVII.

H. v. Meyer described a specimen consisting of four posterior dorsals, the first sacral, and a fragment of the second sacral, from the Rothliegende near Zwickau.

The vertebræ figured by v. Meyer are typically Cotylosaurian. The neural arch is low and broad, with swollen sides and short, stout neural spines. The centrum is much less in width than the neural arches; a keel on the bottom line of the centrum gives it a triangular section at the middle. There are transverse processes on all the presacrals preserved, though that on the last is very small. The anterior sacral vertebra is not smaller than the last presacral and carries a large strong rib. The second was smaller and was closely connected with the first one. The figure shows the similarity to the vertebræ of *Diadectes*.

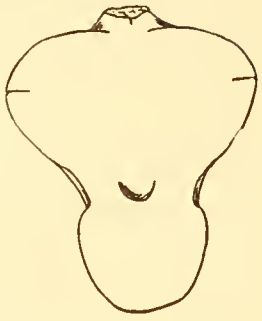


FIG. 15.—Outline of a dorsal vertebra of *Phanerosaurus*. After von Meyer.

Genus STEPHANOSPONDYLUS G. and D.

Phanerosaurus pugnax Geinitz and Deichmüller, Paleontographica, Bd. XXIX, 1882, s. 1-46, pls. 1-IX.
Stephanospondylus pugnax Stappenbeck, Zeitschrift deutsch. geol. Gesell., Bd. 57, 1905, s. 380-437, fig. 35, Taf. XIX.

Skull rounded, triangular, with rounded snout. Parietal foramen very large. Orbits large and elongate oval in outline. Tabulare little developed. Teeth

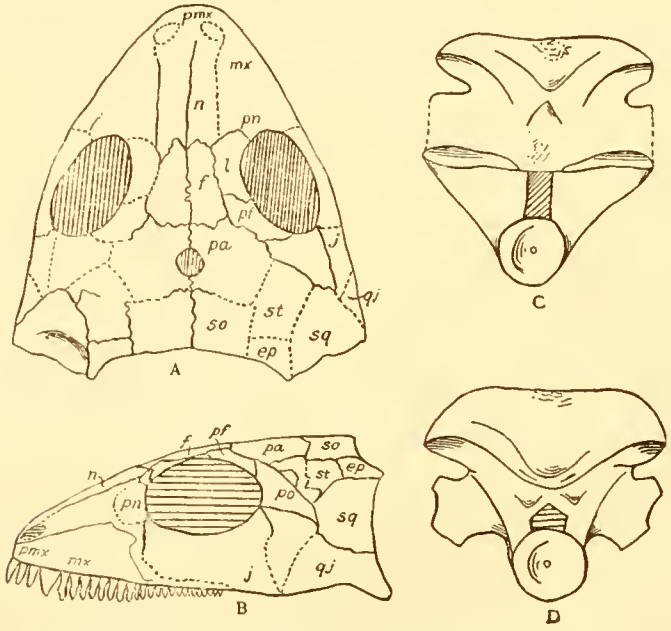


FIG. 16.—Views of *Stephanospondylus*. After Stappenbeck.
A, top view of skull; B, lateral view of skull. Lettering as in former figures.
C, anterior view of a dorsal vertebra; D, posterior view of a dorsal vertebra.

conical, narrowed at base, with labyrinthine arrangement of the enamel. Greatest length of tooth across the axis of the jaw. Acrodont. Incisors simple cones, inclined a little forward. A large canine present. Two rows of cheek teeth in upper jaw. Palate with the curved outer border covered with teeth. Prevomers small, co-ossified. Quadrate plate-like. Vertebræ deeply biconcave, strongly compressed

in middle; in the dorsal region the body united with the arch by suture. Two sacral vertebræ. Ribs single and double head. Clavicle and interclavicle flattened at the proximal ends and the outer surface with a deep-pitted sculpture. Coracoid and procoracoid free. Cleithrum large, neither procoracoid nor pubis take part in the articular cavities. Humerus with articular ends turned at an angle to each other; foramen entepicondylum present. Digits with terminal claws.

The following, from Stappenbeck, shows the difference between *Phanerosaurus* and *Stephanospondylus:*

Stephanospondylus.	Phanerosaurus.
1. Neural arch co-ossified with the centrum.	1. Neural arch united with centrum by suture.
2. Centrum circular in section.	2. Centrum roundly triangular in section.
3. Dorsal vertebræ of equal height before and behind.	3. Dorsal vertebræ lower anteriorly than posteriorly.
4. Sacrals united.	4. Sacrals freely movable.
5. Zygapophyses of anterior sacral of equal size.	5. First sacral with large anterior and small posterior zygapophyses.
6. Articular face for first sacral rib nearly square and vertical.	6. Articular face for the first sacral rib elongate and inclined.
7. First sacral rib flat, both ends enlarged.	7. First sacral rib T-shaped.

Suborder PROCOLOPHONIA (?) Lydekker.

Genus PROCOLOPHON Owen.

Owen, Cat. Foss. Rep. South Africa, 1876, p. 25.
Seeley, Trans. Roy. Phil. Soc., vol. 180, 1889, p. 269.
Broom, Records of the Albany Museum, vol. 1, 1903, p. 8.

Type: In the British Museum of Natural History; other specimens in the Albany Museum, Graham's Town, South Africa.

Skull, short and triangular; the sutures visible. Temporal region with a doubtful temporal opening. Posterior portion of the skull excavated by an epiotic notch, the quadrate not exposed. Pterygoids with external process. Parasphenoid rostrum not showing on the base of the skull. Cheek teeth with broad flattened crowns. Vertebræ amphicœlous, notochordal. Neural arches broad and rounded. Intercentra present. Coracoid, procoracoid, and scapula separate. Ischium and pubis flat and plate-like. Limbs short and stout. Humerus with entepicondylar foramen. The proximal row of the tarsus with two elements, a fibulare and an intermedium ulnare. Phalangeal formula 2, 3, 4, 5, 4.

Genus THELEGNATHUS Broom.

Records of the Albany Mus., vol. 1, 1905, pp. 269-275.

Type: A left maxillary with teeth, the front of the right dentary, and a few other fragments. Preserved in the Albany Museum, Graham's Town, South Africa. From the Middle Trias of Aliwal North, South Africa.

Original description: "In the maxilla there are 6 and possibly 7 molar teeth, and as in *Procolophon* they are anchylosed to the bone. In structure and shape the teeth also resemble closely those of *Procolophon*. They differ however, in becoming steadily larger on passing back. The anteroposterior measurement of the first 6 molars is 17.5 mm. and all the teeth are about 4 mm. high. The maxilla is fairly flat, and measures 27 mm. by 12 mm. It has two fairly large foramina, the first above the interspace between the second and third molars, and the second above the interspace between the fifth and sixth.

"A second specimen shows three maxillary teeth in beautiful preservation. They are probably the fourth, fifth and sixth. The fourth is 2.5 mm. by 4 mm. and

4.3 mm. high. The crown is distinctly constricted anteroposteriorly in the middle, and though a little worn it is fairly sharp. The fifth tooth is 2.8 mm. by 5 mm., and the sixth tooth is 3.5 mm. by 6 mm. The fifth and sixth teeth are less constricted than the fourth.

"The dentary is relatively more slender than in *Procolophon*. There are in the preserved portion 5 teeth remaining, and the sockets of 3 more in front. The 5 measure 17 mm.

"From the shape of the maxillary bone, and from the narrowness of the dentary, it seems probable that *Thelegnathus* had a longer and narrower skull than *Procolophon*."

Genus TELERPETON Mantell.

Mantell, Quart. Journ. Geol. Soc., vol. VIII, 1852, p. 100, pt. IV.
Boulenger, Proc. Zool. Soc., London, vol. 1, 1904, p. 470.

Type: In British Museum of Natural History.

Skull nearly as broad as long, obtusely pointed. Orbits large as in *Procolophon*. No trace of temporal foramina. An epiotic notch not exposing quadrate. No parasphenoid rostrum appearing on the base of the skull. Cheek teeth transversely expanded, bilobate. Intercentra absent. Ribs long and slender. Procoracoid and coracoid distinct from the scapula. Cleithrum absent. Pubis and ischium flat and plate-like. A single element in the proximal row of the tarsus. Phalangeal formula 2, 3, 4, 5, 4.

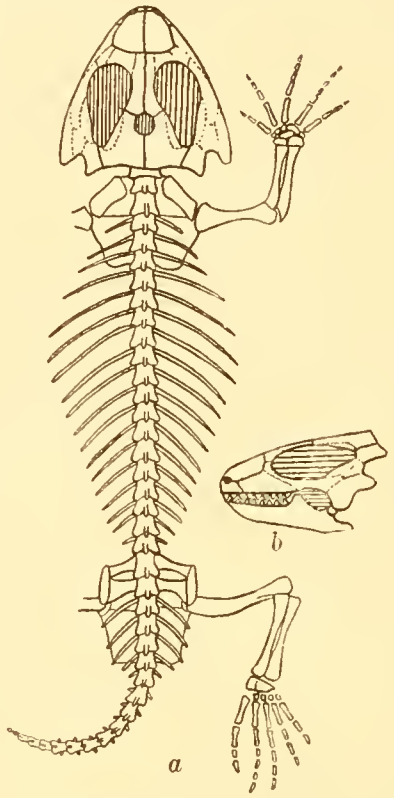


FIG. 17.—Outline of *Telerpeton*. After Boulenger. *a*, restoration; *b*, lateral view of skull.

Suborder PANTYLOSAURIA nov.

1. Skull completely over-roofed.
2. Quadrate covered or exposed, without a posterior hook forming a notch for the external meatus.
3. Prosquamosal present.
4. External process of the pterygoid present and covered with numerous small teeth.
5. Parasphenoid rostrum appearing on the lower surface of the skull.
6. Ectopterygoid absent.
7. Tabulare present.
8. Cheek teeth simple, conical; one or more than one row in each jaw.

9, 10, 11, and 12. Not determinable.

Family PANTYLIDAE nov.

Only the skull known.

1. Slightly larger than the *Captorhinidæ*. Skull cordiform. Quadrate not exposed. Surface with a particularly close, reticulate sculpture.

2. Median incisors very slightly larger than the others. Cheek teeth in the form of blunt, swollen cones; the second or third larger than the others. Posterior cheek teeth small.

3. More than one row of teeth in the jaws.

Genus PANTYLUS Cope.

Bull. U. S. Geol. Survey of the Terrs., vol. VI, art. II, 1881, p. 79.
Trans. Am. Phil. Soc., vol. XVII, 1892, p. 14.

Type: A skull. No. 4330 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The superficial ossification is complete, leaving only nostrils, orbits, and parietal fontanelle. Surface sculptured. Mandible with an angular process. Teeth shortly conic, obtuse, and without grooves or inflections, increasing in size toward the anterior part of the jaws. Mandible supporting several rows of teeth which oppose a pavement of obtuse teeth on the palate. These are situated on either the palatine or anterior part of the pterygoid bones. Quadratojugal and malar bones well developed. No lyra or mucous grooves." The genus was regarded as Stegocephalian in character, but in the next year was placed among the Reptilia (**26**).

In 1892 Cope mentions that *Pantylus* agrees with *Chilonyx* in the composition of the cranial roof, except that the suspensorium is vertical and not directed forward.

Revised description:

1. Skull flat on top with the sides steeply inclined; the posterior surface nearly vertical.
2. Orbits of medium size, near the middle of the skull.
3. Teeth, blunt, swollen cones.
4. Maxillary teeth nearly uniform in size except the second or third, which is larger.
5. Teeth in more than one row in lower jaw and probably in the upper also.
6. Not determinable.
7. Supraoccipital plate vertical.
8. Skull with close reticulate sculpture.
9, 10, 11. Not determinable.

Pantylus cordatus Cope.

Bull. Geol. and Geog. Survey of the Terrs., vol. VI, art. II, 1881, p. 79.
Trans. Am. Phil. Soc., vol. XVII, 1892, p. 25.

Type: Same as the genus.

Original description: "The skull of the *Pantylus cordatus* is about as large as that of the fully grown snapping tortoise, *Chelydra serpentina*, and has somewhat the same form of outline. The vertex is flat; the postorbital region is swollen, and the muzzle is abruptly acuminate. The orbits are lateral with a slight vertical exposure, and are widely separated. The front is deflected from opposite their posterior margins, and the muzzle protrudes considerably beyond the lower jaw. The premaxillary bones form a triangle whose apex does not appear on the superior surface of the muzzle, and the nares are rather close together, and lateral in their vertical presentation. The upper extremity of the snout is occupied by the large nasal bones, which are followed by the larger frontals. The lachrymal and prefrontal are both well developed, the latter extending backwards to meet the postfrontal near the superior border of the orbit. The posterior border of the skull is damaged, but enough remains to show that it was concave. The symphysis mandibuli is short. The rami are wide, and are flat below the inferior surface, forming a rounded angle with the interior surface. The angular process is in line with the external border of the ramus.

"The sculpture of the cranium proper is strong, consisting of pits separated by strong narrow ridges, forming a honeycomb pattern. The fossæ are smaller on

the buccal regions. On the anterior part of the mandible the fossæ are distinct; on the median and posterior part the ridges become linear. A narrow triangular space on the external side posteriorly, with its long apex on the inferior margin, is smooth.

"There are two subequal obtuse teeth, on the border of each premaxillary bone. I can not count the number on the maxillary, but there are four anterior to the line of the anterior border of the orbit. Of these the next to the anterior one is larger than the rest, though of the same shortly conic, obtuse form. These teeth are rather large for the size of the skull. At a point near the middle of the ramus of the mandible, where it is broken off, there may be counted five teeth in a transverse series. Of these the second from the external border is the largest, and has a regularly rounded crown. Six teeth may be counted on a transverse fracture of the palatine bone. Of these the four external have obtusely rounded crowns, and the third from the external border is the largest. The crowns of all the teeth are hollow.

"*Measurements.*

	M
"Length of cranium to transverse line connecting the posterior borders of the quadrates.	0.077
Width between the same points	.082
Length of axis of cranium to line connecting the anterior borders of the orbits	.018
Interorbital width	.032
Longitudinal diameter of the orbit	.016
Length from orbit to nostril	.015
Projection of muzzle beyond mandible	.010
Length of alveolar edge of premaxillary	.007
Height of crown of large maxillary tooth	.0045
Fore and aft diameter of maxillary	.0035
Width of mandibular ramus below at middle	.020"

Revised description: This is contained in the revised description of the genus.

Pantylus coïcodus Cope.

Proc. Am. Phil. Soc., vol. XXXIV, 1896, p. 450.

Type: An injured anterior half of a cranium. No. 4330 Am. Mus. Nat. Hist. Cope Coll. From Texas.

Original description: "The right dental series includes eleven teeth, which are of subequal dimensions. The crowns are robust and somewhat swollen at the middle, and with a small median subacute apex. The matrix covering the palate is rather hard, and in removing it only three internal teeth were detected. Two of these are near the maxillaries, and just within the last and the penultimate respectively. The third is opposite the antepenultimate maxillary and is as far interior to it as the length of the last three maxillaries. This and the posterior palatine teeth are as large as the maxillaries, the other is smaller. The crowns have the same form as those of the maxillary series.

FIG. 18.—Several maxillary teeth of *Pantylus coïcodus*. × 1. No. 4335 Am. Mus. *a*, single tooth of same genus, showing characteristic form. × 3. No. 4336 Am. Mus.

"This species is of about the dimensions of the *P. cordatus*, but the palatine teeth are less closely placed. The inequality in size of the maxillary teeth characteristic of the *P. cordatus* is not seen in the *P. coïcodus*, and the form of the crown in the two species is distinct. Those of the *P. cordatus* are obtuse, and without the little apex of the new species. In the latter the dental crowns have nearly the form of the seeds of grass, *Coix lachryma*.

"Accompanying the specimen above described is a fragment of apparently a dentary bone, which supports eight teeth and parts of teeth. The crowns stand

on shanks which rise above the parapet of the jaw, but have a deeper attachment on the inner side, being thus partially pleurodont. The crowns are swollen at the base as in the maxillary teeth, but the apices are more produced, being regularly conic. The apices are all lost. The teeth belong to a rather larger animal than the one described above, and perhaps to another species.

"*Measurements.*

	M
"Length of a series of eleven maxillary teeth	0.037
Diameters of the crown of a maxillary tooth:	
Longitudinal	.004
Transverse	.003
Distance from ninth tooth to anterior palatine	.006"

Revised description: The specimen shows a row of cheek teeth in a fragment of a badly crushed skull, and several loose teeth in the matrix. It is impossible to tell whether the teeth described by Cope are in position or not. The only character by which these teeth can be distinguished from those of *P. cordatus* is that the apices are drawn out sharply into a fine point. This point would very quickly be worn away and leave the characteristic blunt cone of *P. cordatus;* it is very possible that the presence or absence of the sharp points is but a character of age. The species is very doubtful.

INCERTAE SEDIS.

Genus DESMOSPONDYLUS Williston. (Plate 11, figs. 4, 5.)

Desmospondylus anomalus Williston.

Case, Journ. Geol. vol. VII, p. 718, pl. III, figs. 4a and 4b.
Williston, Bull. Am. Geol. Soc., vol. XXI, 1910, p. 280.

Type: A humerus. No. 6541 University of Chicago. From Vermilion County, Illinois.

This specimen was recognized by Case in 1900 as reptilian in character and probably cotylosaurian. Its publication was reserved for this volume. The discovery of additional material by Williston permitted him to give a more complete description, which is quoted below:

"The vertebræ, of which there are 20 or more centra and fragmentary arches, in addition to the connected series of 7 or 8, present some extraordinary characters—characters which are very suggestive of amphibian affinities, annectant between the rhachitomous and holospondylous types. The centra, coming all of them apparently from the posterior dorsal region and the tail, are short, almost disk-like, deeply concave, with a small perforating foramen. The arches are entirely free; the sutural surface for their attachment is extensive, situated on the anterior three-fourths of the centrum and extending downward on the front margin to below the middle. Back of this sutural surface there is a similar beveled surface extending about one-fourth of the length of the centrum, which also reaches down on the posterior side to the middle of the centrum. The arches are very low, with a rudimentary spine only, resembling the arches of *Labidosaurus* or *Captorhinus*. The zygapophyses are very large and broad, with their surfaces nearly horizontal. Below and back of the anterior zygapophyses there is, on either side, a distinct diapophysis, on the more anterior vertebræ standing out prominently, on the posterior ones a mere rugosity. Lying by the sides of these processes were a number of small ribs, which seem to have been single-headed, inasmuch as no double-headed ribs were found in the matrix. However, as *Labidosaurus* has quite this form of

diapophyses posteriorly with double-headed ribs, it is not impossible that such was the character of the ribs on this genus.

"The anterior border of the pedicel, beginning low down, projects forward, so that if two vertebræ were closely applied the arch would rest on two centra, though chiefly on the posterior one, and, so far as I can determine from careful measurements, this would be the case with the zygapophyses closely interlocked.

"That this was not the condition ordinarily, however, is rendered certain by the presence of extraordinarily large intercentra found in position between several of the centra. Relatively, as compared with the centra, these intercentra are the largest known in any vertebrate, suggesting impressively the lower half of the pleurocentra of *Cricotus*. When in position they reach upward to the middle of the centrum, and almost or quite touch the extremities of the arch. If the ribs were double-headed the capitulum must have articulated with the upper ends of the intercentra. These intercentra are narrower above, so that there is left a distinct free space between the upper parts of the adjacent centra in the horizontal straight position of the column. When curved upward, however, the arches would fill the interstice between the contiguous vertebræ, leaving a wedge-shaped space below, filled with the intercentrum. Some of the centra preserved are hardly more than half the diameter of the largest. They are evidently caudal vertebræ, though no indications of chevrons have been discovered. Others are even more disk-like than the ones figured, resembling so closely various centra attributed to *Cricotus* from the Illinois deposits, that it is probable that they really belong in this genus and are centra, rather than to *Cricotus*, especially so as they agree in size with the femur mentioned above.

"Not only are the vertebræ so curiously intermediate between the ordinary reptilian type and the embolomerous type, but the limb bones, both humeri and femora, were referred unhesitatingly to the amphibians before the vertebræ were recognized. The humerus is extraordinarily stout and rugose for its length. Immediately below the lateral process there is a stout process, hitherto characteristic of certain temnospondylous amphibians, which I have called the ectepicondylar process, most characteristically seen in *Eryops* and *Euchirosaurus*. No such process is known in any Permian reptile, certainly in no Cotylosaurian. Furthermore, the median process is developed into a stout protuberance, quite as in *Eryops*. On the other hand, there is an entepicondylar foramen, remarkable for its large size, known only among amphibians in *Diplocaulus* and *Cochleosaurus*, wholly unrelated forms.

"The femur also is remarkably amphibian in character in the extraordinary development of the adductor crest, a character known in no other Permian reptile. The digital fossa is extraordinary for its extent and depth, reaching nearly to the middle of the bone. The bones identified as tibia and radius (the former was found close to the femur and ilium, the latter in the wash) present no peculiar characters, though remarkably stout and robust.

"Among the material in the wash are fragments of a small skull mingled with *Trimerorhachis* skull material, but there is too much doubt of their reptilian character to make it worth while describing them until further evidence of their identity is forthcoming.

"That the present genus is not a pelycosaurian is, of course, evident; its relationships with the cotylosaurians are more apparent. Nevertheless, the great differences in the structure of both vertebræ and limb bones from anything known among either the diadectid or pariotichid types render the exact position of the genus very doubtful. Possibly, as I have said, it may eventually turn out to be congeneric with some one of the few forms in which the vertebræ and limb bones are yet unknown, especially *Pantylus*."

COMPARATIVE TABLES.

TABLE I.—*Showing the Characters of the Order Cotylosauria.*

CHARACTERS COMMON TO THE PRIMITIVE REPTILES.

1. Vertebræ notochordal or deeply amphicœlous.
2. Intercentra present.
3. Entepicondylar foramen present (except in most primitive forms *Eosauravus* (?) and *Sauravus*).
4. Ischium and pubis flat and plate-like.
5. Five elements in the distal row of the tarsus (when ossified).
6. Abdominal ribs present (?).

CHARACTERS DISTINCTIVE OF THE COTYLOSAURIA.

1. No openings in temporal portion of the skull.
2. Neural arches of the vertebræ broad and low; sides of arches swollen; neural spine low and stout.
3. Teeth tending to become elongate transversely to the axis of the jaw and to become tuberculate.
4. Herbivorous.
5. Body relatively short and low. The limb bones decidedly short and strong with powerful muscular attachment.
6. Neck so short as to be practically absent.
7. Ribs single-headed.

TABLE II.—*Contrasting the Suborders of the Cotylosauria.*

I. *Diadectosauria.*

1. Quadrate and external auditory opening exposed by the cutting away of the posterior edge of the roof of the skull.
2. Upper end of the quadrate bent backward and downward in a hook. External face of the quadrate concave and forming a funnel with its apex at notch formed by hook mentioned.
3. Temporal region covered by two bones, the squamosal and prosquamosal.
4. External process of the pterygoid absent or poorly developed; edentulous.
5. Parasphenoid rostrum not appearing on the lower surface of the skull between the pterygoids.
6. Ectopterygoids rudimentary or absent.
7. Tabulare absent or doubtfully present.
8. Cheek teeth expanded transversely to the axis of the jaw. A single row of teeth in each jaw.
9. Hyposphene-hypantrum articulation present.
10. Coracoid and procoracoid united with the scapula. Cleithrum present.
11. Ischium and pubis broad and plate-like.
12. Abdominal ribs absent (?), not observed in any specimen.

II. *Pareiasauria.*

1. Skull completely overroofed. Quadrate concealed.
2. Quadrate without the hook marking the opening of external meatus.
3. Temporal region covered by two bones, the squamosal and prosquamosal (quadratojugal).
4. External process of the pterygoid present (indeterminable in *Pareiasaurus*), with numerous small teeth.
5. Parasphenoid rostrum appears on the lower surface of the skull between the pterygoids.
6. Ectopterygoid present.
7. Tabulare present, often small.
8. Cheek teeth obtusely conical, one or more than one row in the jaws. Tuberculate or simple.
9. Hyposphene-hypantrum articulation absent.
10. Coracoid and procoracoid united with scapula (free in *Pareiasaurus*).
11. Ischium and pubis broad and plate-like; horizontal or the two sides meeting at an angle.
12. Abdominal ribs present or absent (?).

III. *Pantylosauria.*

1. Temporal region completely overroofed.
2. Quadrate covered or exposed; without a posterior hook forming an external meatus.
3. Temporal region covered by three bones, the squamosal, prosquamosal, and quadratojugal.
4. External process of pterygoid present and covered with small teeth.
5. Parasphenoid rostrum appearing on the lower surface of the skull.
6. Ectopterygoid present.
7. Tabulare present.
8. Cheek teeth simple, conical; one or more than one row in each jaw.

9, 10, 11, 12. Not determinable.

TABLE III.—*Contrasting the Families of the Cotylosauria.*

I. Suborder *Diadectosauria.*

A. *Diadectidæ.*

1. Surface of the skull rugose or tuberculate.
2. Pineal eye enormous.
3. Occipital condyle flat or concave.
4. A more or less complete armor of dorsal plates and plates overlying the ribs.
5. Anterior ribs, at least, expanded into wide plates.
6. Body low and heavy; neck extremely short; limbs stout and clumsy
7. Tail moderately long, with strong chevrons.

B. *Bolosauridæ.*

1. Skull smooth or slightly rugose.
2. Pineal eye small.
3. Occipital condyle rounded.
4. No armor.
5. Ribs not expanded.
6. Body low; limbs short, not heavy.
7. Not determinable.

II. Suborder *Pareiasauria.*

A. *Pariotichidæ.*

1. Small. Skull rounded anteriorly, flattened, amphibian in appearance. Fine sculpture on the bones of the skull.
2. The basioccipital and basisphenoid united and forming a large plate on the base of the skull.
3. Incisor teeth not enlarged. One or two cheek teeth anterior to the orbit larger than the rest. More than one row in each jaw.

B. *Captorhinidæ.*

1. Small, but larger than the *Pariotichidæ.* Skull acuminate, rugose.
2. Basioccipital and basisphenoid small; not forming a large plate on the base of the skull.
3. Incisor teeth much enlarged, tusk-like. Cheek teeth gradually increasing in size to the middle of the series and then decreasing. More than one row in each jaw.

C. *Seymouridæ.*

1. Skull size of that of *Labidosaurus.* A large epiotic notch, quadrate exposed but without posterior hook.
2. Basioccipital and basisphenoid small; not forming a large plate.
3. Median incisors not enlarged. Cheek teeth simple cones, none enlarged. More than one row in each jaw.

III. Suborder *Pantylosauria.*

A. *Pantylidæ.*

1. Slightly larger than the *Captorhinidæ.* Skull cordiform. Quadrate not exposed. Surface with a particularly close, reticulate sculpture.
2. Median incisors very slightly larger than the others. Cheek teeth in the form of blunt, swollen cones; the second or third larger than the others. Posterior cheek teeth small.
3. More than one row of teeth in each jaw.

TABLE IV.—*Contrasting the Characters of the Genera of the Suborder Diadectosauria.*

Family *Diadectidæ.*

Diadectes (in addition to the characters given under the family and suborder).

1. Middle cheek teeth with three distinct cusps. Number of cheek teeth variable. Tooth line sigmoid.
2. Skull with coarse, rugose sculpture; not tuberculate.
3. The third, fourth, and fifth ribs expanded into triangular plates. The sixth, seventh, and eighth overlaid by slender plates.
4. Transverse processes of the vertebræ extending beyond the zygapophyses.

Diasparactus. (Only the vertebræ known.)

4. Transverse processes of the vertebræ not extending beyond the zygapophyses. The centrum relatively small.

Bolbodon. (Only the skull known.)

1. Teeth uncertain, perhaps with a single cusp in the molar series.
2. Skull with finer sculpture; not tuberculate.

TABLE IV—Continued.

Family *Diadectidæ*—Continued.

Chilonyx. (Only the skull known.)

1. Cheek teeth unknown, perhaps cuspate.
2. Skull with coarse sculpture and tuberculate

Desmatodon.

1. Teeth intermediate between *Bolosaurus* and *Diadectes.*

Diadectoides. (Only the vertebral column and hind limb known.) Characterized by small size and stout limb bones.

Family *Bolosauridæ.*

Bolosaurus.

1. Cheek teeth with a single cusp.
2. Skull smooth or slightly rugose.

Family *Nothodontidæ* (uncertain).

Nothodon.

1. Cheek teeth with three cusps.

TABLE V.—*Contrasting the Characters of Genera of the Suborder Pareiasauria.*

Family *Pariotichidæ.*

Pariotichus.

1. Skull low and rounded anteriorly, resembling that of the Amphibia.
2. Orbits large and located near the middle of the skull.
3. Teeth more sharply conical than in the *Captorhinidæ*, but less so than in the Amphibia.
4. One or more cheek teeth anterior to the orbit sharply larger than the rest. Incisors not enlarged.
5. Teeth probably in more than one row in both jaws, but no evidence.
6. Basioccipital and basisphenoid large and forming a broad plate on the base of the skull.
7. Supraoccipital plates standing nearly vertical at the back of the skull.
8. Surface of the skull with fine sculpture.

Ectocynodon (very doubtful).

Distinguished from other members of the family by rectangular interorbital sculpture.

Isodectes.

1. Skull low and rounded anteriorly; amphibian in appearance.
2. Orbits large, located in the anterior half of the skull.
3. Teeth more sharply conical.
4. Indeterminable.
5. Teeth in more than one row in the lower jaws. Maxillary series not visible.
6. Basioccipital and basisphenoid not visible.
7. Supraoccipital plates horizontal in the single specimen.
8. Bones of the skull with a sculpture of fine radiating lines.

Family *Captorhinidæ.*

Captorhinus.

1. Skull more elevated than in *Pariotichus.* More acuminate.
2. Orbits large, in the posterior half or the middle of the skull; looking laterally.
3. Teeth obtusely conical or blunt.
4. Maxillary teeth increasing in size to the fourth or fifth and then diminishing. One or all of the incisor teeth enlarged.
5. Teeth in more than one row in both jaws.
6. Basioccipital and basisphenoid not enlarged.
7. Supraoccipital plates vertical at the back of the skull.
8. Skull with a definite reticulate sculpture.
9. Scapula, coracoid, and procoracoid united.
10. Cleithrum present.
11. Ischium and pubis broad and plate-like.

Labidosaurus.

1. Larger than *Captorhinus.* Skull broader behind and more sharply acuminate anteriorly.
2. Orbits large; near the middle of the skull, looking laterally.
3. Teeth obtusely conical or blunt.
4. Maxillary teeth not differing greatly in size.
5. More than one in each jaw (*fide* Williston).

TABLE V—Continued.

Family *Captorhinidæ*—Continued.
Labidosaurus—Continued.
6. Basioccipital and basisphenoid not enlarged.
7. Supraoccipital plates vertical at the back of the skull.
8. Skull with a reticulate sculpture.
9. Scapula, coracoid, and procoracoid united.
10. Cleithrum absent.
11. Ischium and pubis broad and plate-like.

Family *Seymouridæ*.
Seymouria.
1. The skull a little broader than long; blunt anteriorly.
2. Orbits large, more in the posterior half of the skull than in the middle, looking laterally.
3. Not determinable.
4. Not determinable.
5. Not determinable.
6. Basioccipital and basisphenoid not large.
7. Supraoccipital plates nearly vertical but occupying a considerable space and are on the upper surface of the skull.
8. Skull with definite, reticulate sculpture.
9. Not determinable.
10. Cleithrum absent.

TABLE VI.—*Showing the Characters of the Genus Pantylus.*

Pantylus.
1. Skull flat on top with the sides steeply inclined; the posterior surface nearly vertical.
2. Orbits of medium size, near the middle of the skull.
3. Teeth, blunt, swollen cones.
4. Maxillary teeth nearly uniform in size, except the second or third, which is larger.
5. Teeth in more than one row in the lower jaw and probably in the upper also.
6. Not determinable.
7. Supraoccipital plate vertical.
8. Skull with close reticulate sculpture.
9, 10, 11. Not determinable.

NOTE.

Since the manuscript of this article has been placed in proof two articles have appeared from the pen of Prof. S. W. Williston:

1. Restoration of Seymouria baylorensis Broili, an American Cotylosaur. Journal of Geology, vol. XIX, 1911, pp. 232-237.
2. A new family of reptiles from the Permian of New Mexico. American Journal of Science, vol. XXXI, 1911, pp. 378-398.

In the first of these the author presents a restoration of *Seymouria* and discusses its habits. The family name *Seymouridæ* is proposed without specific characterization.

In the second a new family, *Limnoscelidæ*, based on the genus and species *Limnoscelis paludis*, is proposed from material in the collection of the Peabody Museum of Yale University. The new family belongs in the suborder *Pareiasauria*, as defined in this paper. Its characters as compared with the other families of the suborder are as follows (see table III):

D. *Limnoscelidæ*.
1. Skull large as that of *Diadectes*. Narrowed in front, broad in the temporal region. Not rugose.
2. Basioccipital and basisphenoid large. The latter well formed and separated from the basioccipital by a well-marked suture. Basipterygoid processes large.
3. Incisor teeth large; the median pair the largest. The cheek teeth conical, largest in the anterior part of the jaws. Probably only one row in each jaw.

MORPHOLOGICAL REVISION.

Genus DIADECTES Cope. (Plates 1–9, 14.)

Characteristic specimens: No. 4684 Am. Mus. Nat. Hist.; a nearly complete skeleton lacking skull and foot bones. No. 4839 Am. Mus. Nat. Hist.; a nearly perfect skull. No. 1075 University of Chicago; a nearly complete skeleton, lacking only the feet.

Nos. 4684 and 4839 have been identified as *D. phaseolinus*. No. 1075 can not be specifically identified, but it belongs very close to the above specimens, though smaller. In the following description, which may be taken as that of *Diadectes phaseolinus*, the details are largely taken from the two specimens in the American Museum, as the Chicago specimen has not been cleaned or mounted.

The skull of the genus is represented by numerous more or less complete specimens, but none show the internal structure at all well except No. 4839. This is very perfect, lacking only the premaxillary and the articular portion of the quadrate of the left side. The form of the skull is quite similar to that of *Pareiasaurus*. The posterior end is much wider than the anterior, the sides slope outward and downward, so that the upper surface is narrower than the lower; the distance across the top of the skull in the parietal region is not more than half of that across the articular ends of the quadrate bones. The posterior face falls off almost vertically. The top is flat and descends slightly from the posterior to the anterior end.

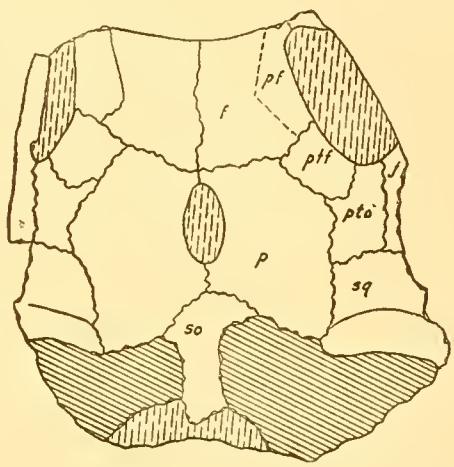


FIG. 19.—Fragment of the top of the skull of *Diadectes* sp., showing sutures. $\times\frac{2}{3}$. No. 4845 Am. Mus.

In most specimens the surface of the skull is covered by a rough sculpture which diminishes anteriorly, but is renewed on the premaxillaries in a series of roughly parallel grooves. The bones are so closely united that the sutures can not be traced on the upper surface. One specimen in the American Museum shows the top of a skull with the cast of the lower surface; on this cast and on the lower surface of the bones the course of the sutures can be traced. The parietals are large plates surrounding the parietal foramen and reaching to the posterior edge of the skull. The supraoccipital and other (indeterminable) bones form the posterior surface. The large squamosal bones articulate with the parietal, postorbital, and jugal; there is no evidence of the presence of a tabulare. Just anterior to the parietal foramen the suture between the parietal and frontal runs nearly straight across the top of the skull and meets the postfrontal on either side. The frontal is kept from taking part in the orbits by the union of the prefrontal and postfrontal.

The parietal foramen is "enormous," as described by Cope. Near the posterior edge of the skull there are deep pits, one on each side, approximately in the line of the suture between the parietal and squamosal. From a study of less perfect specimens these have been reported as probable rudimentary openings, but in these specimens they are certainly closed at the bottom. This character seems to have been extremely variable, recalling the condition in the *Pelycosauria* where the supratemporal opening may be persistent or may be closed.

Posterior aspect: The occipital condyle is wider than long and is excavated on the upper border by the foramen magnum, so that it presents a broad heart-shaped

outline. The articular face for the atlas is concave and there is a deep pit for the continuation of the notochord; it slants downward and forward, so that if it were applied to the atlas without a large preatlantal intercentrum the skull would have been carried almost at right angles to the vertebral column. The foramina for the exit of the posterior cranial nerves are not apparent, but deep pits on the sides of the basioccipital may have led into the openings of the foramina. The limits of the various bones forming the posterior plate of the skull can not be

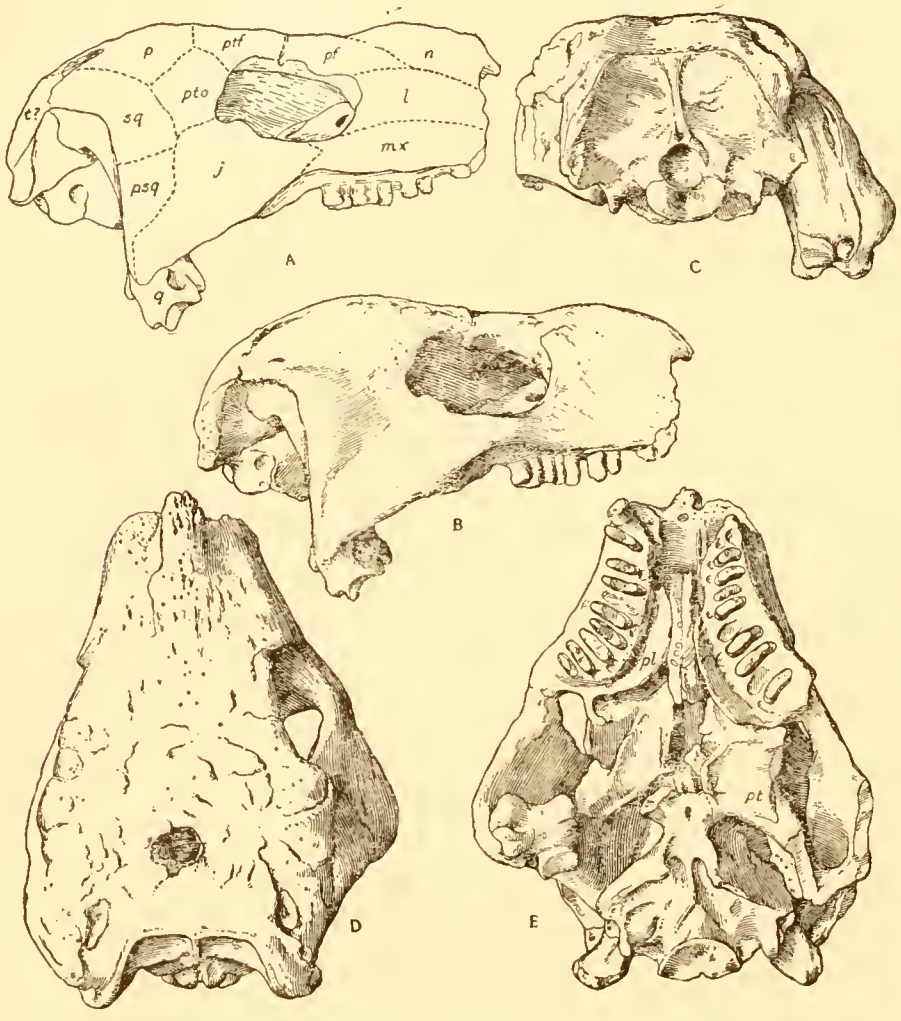


FIG. 20.—Skull of *Diadectes phaseolinus*. × ⅓. No. 4839 Am. Mus.
A, lateral view, showing probable arrangement of sutures; B, lateral view; C, posterior view; D, top view; E, lower view.

made out, as the sutures can not be traced, but it is apparent that the paroccipital bone was short, and joined, almost at once, the descending processes of the squamosal and the quadrate. I have described two perforations in the posterior portion of the skull in the position of posttemporal foramina and likened the condition to that of the turtles (Case 15); in this specimen I find only two deep pits in this position.

Lateral surface of the skull: The quadrate rises almost vertically, the anterior border is attached to and somewhat overlapped by the bones of the postorbital

region. Near the upper end the quadrate turns to the rear and joins a process of the paroccipital; the turn in the quadrate is marked by a sharp angle quite similar to that seen in the same position in the turtles. No traces of a columella was found and if present it must have been very short. The opening of the auditory canal can not be made out, but it must have been almost opposite the angle described.

The outer face of the quadrate is concave, forming a funnel-like cavity with the apex at the notch described above. The whole surface of this concave face is smooth, and anteriorly it is overlapped somewhat by the posterior edge of the squamosal The posterior edge is covered by a bone whose upper limits can not be determined, but which is separated from the quadrate below by a quadrate foramen of good size. The articular face of the quadrate for the lower jaw is wider than long, convex, and is divided into nearly equal parts by a shallow groove running anteroposteriorly.

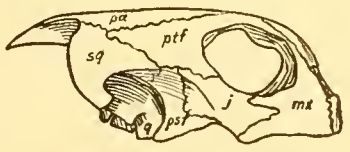


FIG. 21.—Lateral view of skull of *Chelone midas*.

The sutures between the bones are no more distinct than on the superior surface, but the slight crushing of the specimen has caused some of the bones to break apart slightly, and this with some slight traces of sutures warrants the following conclusions as to bones of the side of the skull.*

The *squamosal* is continued backward at the upper end in a process which overhangs the quadrate and may contain the tabulare, but there is no suggestion of a division. This portion of the bone bears a striking resemblance to the same region in the turtles. The anterior edge of the squamosal is convex forward and joins the postorbital and prosquamosal.

The *prosquamosal* covers the quadrate below and articulates posteriorly with the bone which covers the posterior surface of the quadrate and is separated from it by a foramen; this I consider the quadratojugal. Anteriorly, the prosquamosal articulates with the jugal. It will be seen that this bone occupies the position occupied by the quadratojugal in many reptiles. The reason for considering this bone to be a prosquamosal is given in the discussion of the genus *Captorhinus*, where the position and form of the bones are shown much more clearly (see p. 94).

The *quadratojugal* lies on the back of the skull, covering the posterior surface of the quadrate and separated from it by a large quadrate foramen; its limits can not be made out, as no sutures are traceable on the outer surface of the skull. This interpretation of the temporal region of the skull is radically different from that assumed by Cope. He believed that the *Diadectidæ* had the full complement of bones, such as he figured in *Captorhinus* (*Pariotichus*), and upon this basis considered the *Cotylosauria* as possessing the most primitive type of skull, the one from which all other reptilian types were derived. The impossibility of the *Cotylosauria* occupying such an ancestral position is apparent, and the equal impossibility of any other known form from the Texas Permian occupying such an ancestral position is demonstrated in the discussion of the different groups.

The *jugal* forms the lower edge of the orbit; the suture between it and the maxillary is not certain.

The *maxillary* probably forms a part of the lower edge of the orbit. It does not reach far up on the side of the facial region. The number of teeth in the upper jaw, maxillary and premaxillary, is given in the following list as accurately as they

*In this determination I was aided by Dr. Broom of Victoria College, Cape Colony, and as we reached a perfect agreement on the determinations it is advanced with some confidence. He gives, however, different names to some bones, as quadratojugal for the bone called here prosquamosal. In his recent paper (10a) he gives a figure of sutures differing slightly from the figure here given, fig. 20, *A*.

can be determined. These figures are in part estimates, as the upper jaws are imperfect in some specimens.

	mm
No. 4350 Am. Mus., *D. molaris*	14
No. 4349 Am. Mus., *D. phaseolinus*	14
No. 4839 Am. Mus., *D. phaseolinus*	14
No. 1078 Univ. of Chicago *Diadectes* sp	14 to 15

In all members of the genus the posterior tooth is smaller and more simple than the other cheek teeth. The next seven or eight have the form characteristic of the family and are described in detail under the various species. The anterior teeth of the maxillary series become smaller and the root rounded in section, leading Cope to the suggestion that some specimens had a distinct, enlarged canine. The posterior premaxillary teeth were of the same form, cones slightly flattened transversely. The three anterior incisors were larger and elliptical in section, but attrition speedily produced flat, concave faces on the outer side of the upper teeth and corresponding surfaces on the inner side of the lower. These teeth were as eminently fitted for cropping herbage as the posterior teeth were for crushing it. It is to be noted that only in old specimens is there much evidence of wear on the cheek teeth; the tubercular and cuspate tops, which did not fit accurately upon those of the opposite jaw, are singularly well preserved. This indicates the absence of any grinding action of the jaws and coincidentally the lack of use of hard or tough vegetation as food. Perhaps the animals fed upon succulent water plants or upon soft, easily crushed shellfish. The wear of the teeth produced flat faces on the inner cusps of the lower teeth and in advanced stages a deep triangular groove on the inner side of the middle cusp. The same effect was produced on the outer half of the upper teeth.

All the teeth were placed in well-defined sockets. The root is fairly long and shows a distinct longitudinal corrugation of the surface (plate 6, fig. 2). Several specimens show successional teeth rising to displace functional ones.

The *lachrymal* was elongate, reaching from the orbit to the nares. It sent a process upward from its posterior end, partly separating the prefrontal and the nasals. Just within the edge of the anterior part of the orbit is a good-sized lachrymal foramen.

The *prefrontal* formed more than half of the upper rim of the orbit and did not extend very far anterior to it.

Lower surface of the skull: The *basioccipital* is separated from the basisphenoid by an indistinct suture. The *basisphenoid* ends abruptly in front, just anterior to the basipterygoid processes. There is no presphenoid rostrum apparent on the lower surface of the skull; a short and very stout process, excavated longitudinally on its lower surface by a deep pit, is attached to the anterior end of the basisphenoid. In other specimens the anterior end of the basisphenoid is perfectly smooth. The lower surface of the basisphenoid is penetrated in the median line by a single foramen; in the *Pelycosauria* and *Rhyncocephalia*, generally, there are two foramina in this place for the passage of the internal carotid arteries. In other specimens of *Diadectes* I have been unable to detect any foramina at all in this position, but its apparent absence was probably due to the condition of the specimen. Posteriorly the basisphenoid widens and the posterior edge is continued backward as a sort of flange overhanging the basioccipital. The flange is excavated by a notch in the median line, and the notch is divided by a narrow partition which is continued backward as a narrow ridge on the surface of the basisphenoid and then divides, probably following the basioccipital-basisphenoid suture. On either side of the

dividing partition there is a deep pit, probably the openings of the Eustachian canals. In the *Pelycosauria* the canals open into a single median pit.

Posterior to their articulation with the basipterygoid processes of the basioccipital the *pterygoids* pass backward as vertical plates to join the quadrate, but the vertical plates are curved so far as to follow approximately the outer wall of the skull, leaving no great space between them. Anteriorly, the pterygoids nearly, but not quite, meet in the median line; passing forward they articulate with the inner edges of plates attached to the maxillaries, and continuing forward pass above these plates so that they are underlaid by them. These plates occupy the position of *palatines* and probably are such, but their position underlying the pterygoids is very peculiar. In other specimens, No. 1078 University of Chicago, an imperfect *ectopterygoid* can be traced, but none can be made out in this specimen. It is a very small element lying between the outer end of the pterygoid and the maxillary.

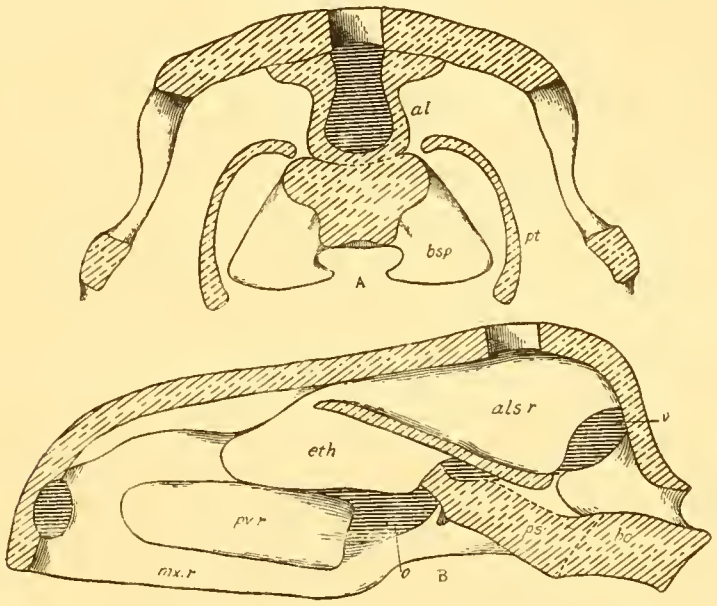


FIG. 22.—Skull of *D. phaseolinus*. × ½ No. 4839 Am. Mus.
A, transverse section; B, longitudinal section of same. *al*, alisphenoid; *als.r*, alisphenoid of right side; *bsp*, basisphenoid; *bo*, basioccipital; *eth*, ethmoid; *pt*, pterygoid; *pv.r*, prevomer of right side; *mx.r*, maxillary of right side; *o*, orbit; *v*, opening for escape of cranial nerves.

Between the palatines (maxillary plates of Cope) there is left quite a space, in which lie the *prevomers*. These are vertical plates of considerable height, but very narrow on the palatal surface. Towards the posterior ends the upper edges of the plates flare outward to join the palatines or pterygoids, but at the anterior end the plates are vertical and parallel; the upper edge touches the lower edge of a median vertical plate described below. There are traces of a few large conical teeth on the prevomers, but they are sparse and irregularly arranged.

Longitudinal section of the skull: The brain case shows the sharp downward bend posterior to the epiphysis described by Cope in his account of the cast of the brain cavity. Anterior to the optic region there is a very large foramen which gave exit to the seventh nerve; it is likely that other nerves escaped through the same opening. Anterior to this foramen the walls of the brain case are formed by solid elements, the *alisphenoids*, which are attached to the under side of the roof above and to each other and the basisphenoid below. They may be traced as far forward

as the anterior edges of the orbits. Just anterior to the epiphysis of the brain the bones of the two sides meet below, inclosing a long narrow cavity which remains open in front. This sheltered the great elongation of the nasal lobes and the anterior portion of the brain shown in Cope's cast.

Anterior to the basisphenoid and joining the short anterior rostrum is a single vertical plate. This ends somewhat abruptly behind, where it joins the basisphenoid but extends upwards until it touches the alisphenoids above. It remains in contact with these bones to their anterior ends and from there forward is joined by cartilage to a prominence on the lower surface of the nasals. The lower edge of its anterior half is in contact with the upper edges of the prevomers. This bone is similar in all respects to that figured by Broom in *Lystrosaurus* and by the author in *Dimetrodon* as the *ethmoid* or *true vomer*. It is in direct continuation with the parasphenoid rostrum, if it is not an actual part of it.

The brain: The following account of the brain is transcribed directly from Cope's account (30).

"The brain-case in the *Diadectidæ* differs from that of the *Clepsydropidæ* much as that of the *Varanidæ* differs from those of other *Lacertilia*. That is, it is continued between the orbits, so as to inclose the olfactory lobes of the brain within osseous walls. These walls are thin; especially at the interorbital region, and in the specimen the anterior extremity is so far imperfect as to leave the form of the anterior fundus in doubt. * * *

"The formation of the cranial walls requires preliminary notice. In the first place the vestibule of the ear can only have been separated from the brain by a membranous septum, as is the case in the *Protonopsis horrida** (*Menopoma*). In clearing out the matrix no trace of osseous lamina could be detected on either side and the edges of the huge foramen thus produced are entire, and present no broken edges. Anterior to the vestibule, the prootic bone has a small extension, terminating in a vertical border. In front of this is a huge vertical foramen through which issues the trigeminus nerve which is even larger than that found in the *Testudinata* and *Crocodilidæ*. The anterior border of this foramen is formed by the probable alisphenoid, whose posterior edge is nearly parallel with the anterior border of the prootic, sloping forwards as it descends. The basicranial axis is thin at their union on the middle line below, and, thickening forwards, is excavated by a rather small conical fossa. Anterior to the fossa is a smaller impressed fossa, and on either side of it, each lateral wall is excavated into a shallow fossa which descends towards it. The frontoparietal fontanelle is of extraordinary size.

"I. THE BRAIN.

"When the superior border of the medulla oblongata at the foramen magnum is placed horizontally, the axis of the brain ascends at an angle of 45° towards the frontoparietal fontanelle. The superior surface, anterior to the foramen magnum, is subquadrate in outline, the angles being truncated, and directed anteriorly, posteriorly, and laterally. A posterior constriction connects it with the medulla; and an anterior one defines the middle brain and hemispheres. Each lateral truncated angle represents the foramen of the trigeminus nerve. The space thus bounded is divided into two nearly equal areas by a transverse groove, which extends from the posterior edge of one of these foramina to the other. The posterior of these I suppose to represent the cerebellum, and the anterior the optic thalami. The cerebellar surface indicates that, as in many lizards, the cerebellum is simple, and very slightly convex.

* See Journal Academy Philadelphia, 1866, p. 105, where the characters of the skull in the *Urodela* are pointed out.

"Anterior to the foramen trigemini, the brain contracts so as to have a transverse diameter scarcely more than one-third its vertical diameter. The cast at a point twice as far in advance of the cerebellar line as the fore-and-aft width of the cerebellum, rises to fill the frontoparietal foramen, forming a mass which represents the huge pineal sac or epiphysis. The proportions of this body are even greater than they are in any of the existing *Lacertilia*, and it has a greater transverse diameter than the middle brain inferior to it. Its posterior border is at right angles to the line continued forwards from the superior border of the medulla oblongata at the foramen magnum. At its posterior base a flat horizontal processs, as wide as the brain at this point, extends posteriorly in a corresponding fossa of the superior cranial wall. Its posterior margin occupies a transverse groove of the superior wall between the superior and inferior plates. Each lateroposterior angle is produced, and may represent the foramen of exit of a narrow canal which appears to perforate the lateral wall and issue beneath the roof of the temporal fossa. A large projection of each side of the base of the epiphysial mass occupies a large foramen of the lateral wall, which has the superior wall for its superior border. This may only represent a vacuity of the wall, but the fossa at the posterior base of the epiphysis has greater significance. What this is I am at present unable to ascertain.

"Below the epiphysis the transverse diameter of the brain is about one-fourth the vertical, not including a short inferior prominence. The latter is small and conical, and is situated below the center of the epiphysis when the cerebellar surface is placed horizontally, or in front of it, when the medulla at the foramen is placed horizontally. Its significance is unknown to me, as it is anterior to the position of the hypophysis. A thickening of the cast on either side of its base converges to the median line posterior to it. I can find no optic foramina, and believe, therefore, that the optic nerves issued from the same large sinus as the trigeminus. The cast diminishes in vertical diameter anterior to the inferior conical process, and increases in transverse diameter of its superior surface. The inferior border continues to be keel-like, so that a vertical section is triangular with the base superior. It is impossible to distinguish the outlines of the cerebral hemispheres or the olfactory lobes, both of which are probably included in this part of the cast, although the latter probably extended much anterior to the extremity of the brain case as preserved. The form may or may not give an idea of the forms of the hemispheres. In any case they were narrower than in any known reptile.

"The prominent features of this brain are then the following: The widest part is at the origin of the trigeminus nerve. Both the cerebellum and optic thalamus are flat and simple. The hemispheres are narrower than the segments posterior to them and of greater vertical diameter. The epiphysis is enormous, and sends a process posteriorly between the tables of the parietal bone. The olfactory lobes were apparently large, and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and Batrachia rather than of reptiles, but the thalami are also smaller than is the case in Batrachia. The small, flat cerebellum is rather batrachian than reptilian.

"2. THE AUDITORY APPARATUS.

"As already remarked, the internal wall of the vestibule is not bony, so that the cast of the brain cavity includes that of the vestibule also. On the external wall of the latter are the orifices of the semi-circular canals. These are, one double fossa at the superior-anterior part of the wall; a second double one at the posterior-superior part of the wall, and a single orifice at the inferior-posterior part of the wall. The external part of the vestibule is produced upwards and outwards to the

fenestra ovalis. The "double fossæ" above mentioned are the osseous representatives of the membranous ampullæ at the junction of two pairs of semicircular canals.

"On sawing open the periotic bones, which here form a continuous mass, the following is seen to be the direction of the semicircular canals. The superior canal is horizontal. The second canal, from the posterior ampulla, descends forwards and, after a course a little longer than that of the horizontal canal, turns posteriorly. The inferior canal from the anterior ampulla also descends and, after a shorter course than the canal last mentioned, also turns backwards and joins it, the two forming a single canal, which enters the vestibule by the single posterior foramen already described. The lumen of the longer perpendicular canal is much larger than that of the others. As its ampullar orifice is also the largest of all, I suppose this increased diameter to be partly normal; but it may be partly abnormal, as its walls are irregular and rough.

"The fenestra ovalis is not preserved in this specimen, but can be seen in the crania of the species *Diadectes phaseolinus* and *Empedias molaris* above mentioned.* The vestibule or a diverticulum from it is produced upwards and backwards, and terminates in a round os. This is clearly not a tympanic chamber, nor is it a rudimental cochlea. It does not appear to be homologous with the recessus labyrinthi, since that cavity is not perforated by the fenestra ovalis. It appears to be a prolongation outwards of the vestibule and sacculus, which may be observed in a less degree in the genus *Edaphosaurus* (Cope), also from the Texas Permian formation. Here the adjacent bones are produced slightly outwards, and the fenestra ovalis is closed by a large stapes similar in external form to the one I have described in the *Clepsydrops leptocephalus*.† Its more intimate structure I have not yet examined.‡

"The result of this examination into the structure of the auditory organs in the *Diadectidæ* may be stated as follows: The semicircular canals have the structure common to all *Gnathostomatous Chordata*. The internal wall of the vestibule remains unossified, as in many fishes and a few batrachians. There is no rudiment of the cochlea, but the vestibule is produced outwards and upwards to the fenestra ovalis in a way unknown in any other family of vertebrates."

The *lower jaws* (plate 4, fig. 2) of specimen No. 4684 are nearly complete, lacking only the articular region of the left side. There are three pairs of large incisors (the median pair the larger) and eleven cheek teeth. In specimen No. 1076, University of Chicago, there are three incisors and twelve cheek teeth; the discrepancy is probably due to the loss or obscuration of a tooth in No. 4684. The incisors have a greater anteroposterior diameter than transverse and the inner side shows a worn surface. The front two teeth after the incisors are small with a single cusp, but rapidly increase in size posteriorly through the third, fourth, fifth, and sixth; the seventh is the largest, the tenth and eleventh are abruptly smaller. The shape of the tooth is well shown in the figure of the type (plate 1, fig. 6, 6*a*). Opposite the largest teeth the jaw is widened, not only by the increase of the alveolar surface but by the retreat of the tooth line from the outer edge of the jaw, which remains nearly straight. The separate bones of the jaw can not be made out; they

* See skull of *E. molaris*, Proc. Amer. Philosoph. Society. 1881, plate v, figs. *a* and *b*, where the fenestra is represented.

†See Proc. Amer. Philosoph. Society, 1884, p. 41.

‡Professor Owen has figured (Todd's Encyclopedia, art. Monotremata) a structure in *Echidna*, which looks remarkably like that here described. This is a tubular elongation of the meatus auditorius externus with more or less cartilaginous walls. This structure might be regarded as homologous with that displayed by the *Empedias*, could we imagine that with their diminution in size in the Monotreme, the ossicula auditus had retreated within this tube preceding the membranum tympani, from a position at its distal to one at its proximal extremity. But such a supposition has as yet no foundation, and the very similar parts in the two types may have no homology.

are as closely united as are the bones of the skull. Just within the low coronoid process there is a large opening on the inner surface of the jaw admitting to a large cavity and a second one on the same side near the anterior end. The outer surface of the jaw is covered with a rough irregular sculpture.

The lower jaw of specimen No. 1076 University of Chicago (plate 6, fig. 3) differs in some details from that of No. 4684 Amer. Museum. The jaw is singularly testudinate in general appearance. The anterior portion is relatively very high and the coronoid process is inconspicuous. The anterior portion of the jaw descends slightly to the symphysis, which is narrow, sutural, and formed almost entirely by the dentary. Just anterior to the coronoid there is the enormous posterior opening of the Meckelian cavity, and (a short distance anterior to this) a second opening. The narrow bridge separating the two is probably formed by the dentary. The alveolar border is broad and the teeth are placed near the inner edge, being separated from the raised outer edge of the dentary by a shallow groove. It is impossible to determine the outline of the separate elements.

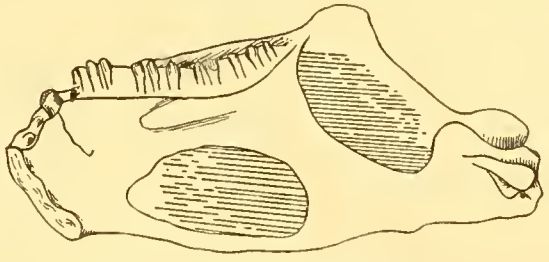


FIG. 23.—Inner view of right lower jaw of *Diadectes* sp. × ⅔. No. 1076 Univ. of Chicago.

There are eleven cheek teeth and at the posterior end the alveolus for a small one. Anterior to these is a single incisor and alveoli for four more, making sixteen in all. This is more than in other specimens.

The *vertebral column* (plate 4, fig. 3; plates 6, 14). The complete presacral portion of the column in the University of Chicago specimen, No. 1075, has twenty-one vertebræ. The American Museum specimen, No. 4684, lacks the atlas and axis and there is one break in the column where the parts do not fit. As mounted, this specimen has twenty vertebræ. There are two sacrals and a large number of caudals, thirty-three in the specimen as mounted, but ten of these are restored in plaster to supply evident gaps. The exact number is uncertain.

The *atlas*, determined in part from specimen No. 1075 University of Chicago, has a simple disk-like centrum with the neural arch free and separated into two halves. As described above, the articular face of the occipital condyle is strongly inclined to the axis of the skull, so that there must have been a large preatlantal intercentrum to enable the skull to be held in line with the body. The neural arches strongly resemble those of *Dimetrodon;* they are semicircular in shape; the inner face is divided by a ridge into an upper half which protected the spinal cord and a lower half which articulated with the centrum. The anterior end of the upper half extended forward so as to touch the surface of the skull just above the foramen magnum. On the outer surface of each half is still attached the broken anterior zygapophysis of the axis. Articular faces for ribs can not be detected.

The *axis* has the neural spine only slightly higher than those of the succeeding vertebræ, but of very different form. It is thin laterally and of considerable anteroposterior extent. The posterior edge is thicker and nearly vertical, but the anterior edge slopes downward and forward and terminates in a very thin margin, possibly extending between the halves of the neural arch of the atlas. The anterior zygapophyses are small, the posterior full size, and the articular faces of both are horizontal. There are well-developed transverse processes. The intercentrum between the axis and the atlas was small; this seems to have been the condition throughout the column with the exception of the preatlantal intercentrum.

The *third* vertebra has the posterior zygapophyses more obliquely placed. The spine is stout and short, somewhat diamond-shaped in section, with the edges anteroposterior. The sides are very rugose and there is on each side a triangular flap extending to the rear to increase the surface for the attachment of the nuchal ligament. The transverse process is short and there is a very short face for the tuberculum of the rib on its distal end. There is no face for the capitulum, though there was a well-developed head on the rib; it must have been attached to the intercentrum. The lower edge of the transverse process is not free from the centrum, but attached to it by a broad thin plate of bone, as is so characteristic for the whole group. The centrum is round in section and there are no median or lateral keels on the surface. It is shorter below than above, leaving a space for the intercentrum.

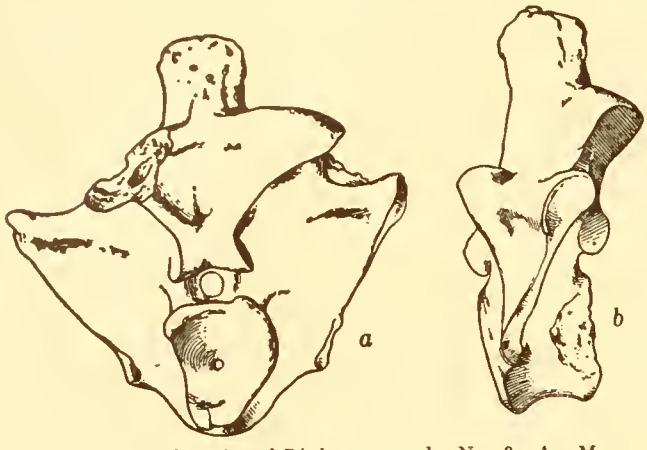


FIG. 24.—Dorsal vertebra of *Diadectes* sp. × ½. No. 4840 Am. Mus. *a*, anterior view; *b*, lateral view.

On the *fourth* cervical the anterior zygapophyses are oblique, but the posterior ones are horizontal. The spine is shorter and stouter than that of the third. The transverse process is wider, but still supports only a single facet for the rib. On the anterior edge of the centrum, near the bottom, is a facet for the capitulum of the rib.

In the *fifth* the facet for the capitulum is united with the one on the transverse process by a very narrow ridge; this corresponds with the fact that the capitulum and tuberculum are practically united in the rib.

All the vertebræ of the presacral series have the strong hyposphene-hypantrum articulation in addition to zygapophyses. This structure was first described by Cope in the dinosaurian genus *Amphicœlias* as follows:

"The anterior zygapophyses are separated by a deep fissure, while the posterior zygapophyses are united on the middle line. From the latter, from the point of junction, there descends a vertical plate which rapidly expands laterally, forming a wedge whose base looks downward. The supero-lateral faces are flat, and articulate with corresponding facets on the inferior side of the anterior zygapophyses, which look downward and inward, on each side of the fissure above described. When in relation, the anterior zygapophyses occupy a position between the posterior zygapophyses above, and the hyposphene, as I have termed the inferior reversed wedge, below. This arrangement accomplishes the purpose effected by the zygosphenal articulation—that is, the strengthening of the articulation between the neural arches, but in a different way. The additional articulation is placed at the opposite extremity of the vertebra, and it is the anterior zygapophysis instead of the posterior which is embraced."

In the *sixth* the two facets on the transverse process are completely united and the vertebra has taken on the character of a true dorsal. The wide, wing-like transverse processes bear a single face which slopes downward and forward as well as inward. The upper part of this facet is much broader in the anterior vertebræ, but gradually decreases until in the mid-dorsals and posterior dorsals it is only at the extreme upper end that this can be noticed. Throughout the series the rib heads are not so long as the faces on the transverse processes; there was evidently

a considerable quantity of cartilage present in the joint. The centrum is more oval in section than in those anterior to the sixth. The spines of the vertebræ from the sixth to the twelfth are exceptionally low and stout, with the distal ends very rugose, either with a median notch or the top expanding like a mushroom, evidently to afford attachment to strong ligaments or perhaps to overlying dermal plates.

With the *thirteenth* the vertebræ are broader and have less anteroposterior extension of the neural arches and zygapophyses. At the same time the neural arch and spines become higher, so that the whole posterior dorsal series looks thinner and more elevated than the anterior. The articular faces of the transverse processes here begin to shorten and on the fifteenth and sixteenth they reach forward to top of centrum; the lower end no longer passes gently into side of centrum, but stands out abruptly from it. This continues to the twentieth, and on the twenty-first, the first presacral, the transverse process is suddenly shortened and fused with a very short rib.

There are two *sacrals*. The spines are abruptly bent backward, leaving a considerable space between the first sacral and the straight spine of the first presacral. The anterior zygapophyses of the first sacral are full-sized, but the articulation between the two sacrals is so close that the zygapophyses have practically disappeared. The rib is very stout and strong and the distal end is widely expanded and applied to the inner surface of the ilium. The rib of the second is smaller, the distal end less expanded, and it appears to be, in part at least, applied to the expanded surface of the first rib. The intercentrum between the two is fused with the centra.

The *first caudal* has the spine sharply curved backward, resembling in this respect the sacrals. The ribs are stout and fused with the transverse processes. The anterior zygapophyses are small, but larger than those between the sacrals. The hyposphene and hypantrum are small but distinct.

In the *second caudal* the spine is still recurved and the zygapophyses are large and well formed, but there is no trace of the hyposphene and hypantrum. The ribs are elongate and sharply bent to the rear.

The *third to fifth caudals* diminish regularly in size; the spines are straight and the zygapophyses are proportionately larger than in the first two. The transverse processes are large, increasing the width of the vertebræ. The ribs of the fourth and fifth are reduced in length. The first chevron appears between the fourth and fifth, or the fifth and sixth, and continues to the extremity of the tail.

The *sixth to ninth*. The transverse processes are much shorter and with the rudimentary ribs stand straight out from the side of the centrum. The centrum is shorter, so that these vertebræ look wider than those before or behind.

On the *tenth* is the last trace of a rib; behind this there are only rudiments which rapidly disappear. The vertebræ from the tenth to the *twenty-fifth* are similar to the tenth; retaining the high spines as they diminish in size, they are more slender in appearance.

Twenty-sixth to thirty-third. There are thirty-three vertebræ in the tail as mounted; ten of these are plaster models, necessary to complete the sequence, and there were probably a few, four or five, missing at the tip of the tail. Shortly after the twenty-fifth the vertebræ lose their spines and assume an elongate form, though they never approach the proportion seen in forms with elongate, taper tails.

The *chevrons* are exceptionally large and lie fairly close to the centra. The upper end is perforated by an elongate foramen which is not complete above, in the anterior part of the tail, but in the middle and posterior part of the tail is closed.

The ribs. Imperfect remains suggest that the ribs of the atlas and axis were fairly long and slender. That of the *third* was an elongate plate of triangular form with the anterior edge straight and an angle to the rear overlapping the rib of the

fourth vertebra. The capitulum and tuberculum are distinct, the first reaching to the intercentrum and the latter touching the end of the transverse process. The *fourth* resembles the third, but is much larger. The capitulum and tuberculum are separated by a slight notch only. The capitulum is attached to the facet on the anterior edge of the fourth vertebra. The whole rib is larger and the point on the posterior edge larger than the third.

The *fifth rib* is much larger than the third and fourth, but the posterior prolongation is less marked than on the fourth. The capitulum and tuberculum are hardly distinct, thus corresponding to the position of the facets on the vertebra; the one on the anterior edge of the centrum extends backwards toward the one on the short transverse process until the two nearly meet. The expanded ribs overlap each other from before backwards, forming a strong protection for the thoracic region (plate 8, fig. 1).

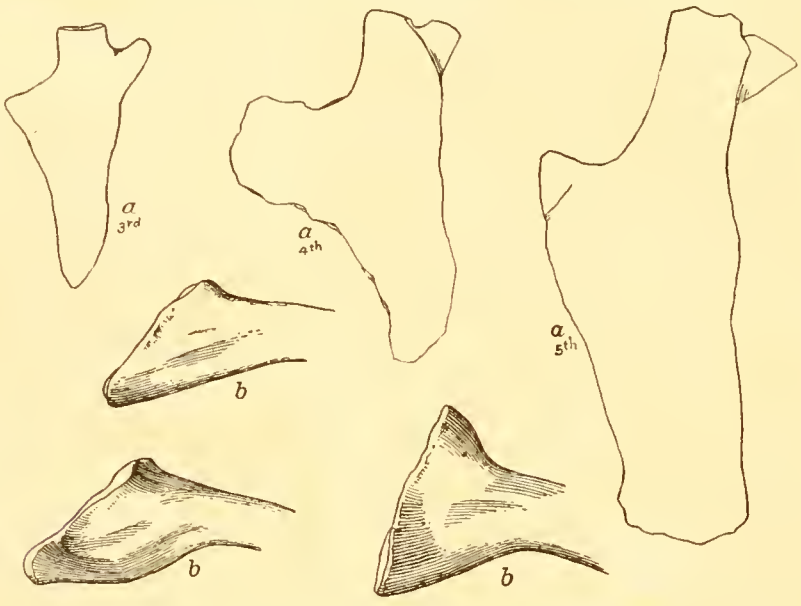


FIG. 25.—*a*, Third, fourth, and fifth ribs of *Diadectes phaseolinus*. × ½. No. 4684 Am. Mus. *b*, heads of three dorsal ribs of same specimen.

Posterior to the fifth, the ribs become normal in form. The sixth is nearly or quite the longest and beyond this the ribs gradually shorten. The tuberculum and capitulum are united in a single facet, but in no place is the face on the end of the rib as long as the face on the transverse process; the lower end of the rib face was attached to the transverse process by cartilage.

Overlying the *sixth*, *seventh*, and *eighth* ribs were thin, elongate dermal plates which overlapped each other from before backwards and carried the protection of the thoracic region backward as far as the distal end of the scapula (plate 5, fig. 5). In the previous description of *Diadectes* by the author (13) it was stated that there were five plates overlying the anterior ribs. This was an error due to the condition of the specimen in which the scapula overlay the ribs, and the edges of the expanded fourth and fifth ribs were mistaken for the edges of plates. Later, the scapula was removed from one side and the true condition made out. The condition of the ribs and the overlying plates is now known from two specimens.

In connection with the plates overlying the ribs should be mentioned the condition of the neural spines. In all specimens of *Diadectes* the upper ends of the spines are expanded and rugose, suggesting very strongly the presence of a row of dermal plates down in the middle of the back. The spines appear much the same as those of *Pareiasaurus*, in which such a row of plates is known to occur.

The *shoulder girdle* is best known from No. 1075 University of Chicago, but the imperfect girdle of No. 4684 American Museum verifies the determinations. As a whole, the thorax was very narrow; the clavicles and interclavicle are tightly bound together and in the University of Chicago specimen retain their position undistorted, showing the space between the clavicles to have been relatively small. The shortness of the neck brought the anterior end of the clavicles very close to the angle of the lower jaw.

The *interclavicle* (plate 5, fig. 3) is an elongate bone, rather oval in section, terminating posteriorly in a slightly rugose point. The anterior end was thickened and somewhat expanded; its upper surface was smooth, but the lower face was marked by a deep notch the sides of which are formed by the thickening necessary to accommodate the articular surfaces for the clavicles.

The *clavicles* are thickened at the proximal end, where they unite with the interclavicle and with each other anterior to the interclavicle. The union of the clavicles and interclavicle is very close and is accomplished by strong interlocking processes. Beyond the articulation, the clavicles extend out from the interclavicle horizontally for a short distance and then bend sharply to the rear. There are no articular faces at the point of contact with the scapula and cleithrum, but where the blade of the clavicle turns, the upper edge is bent inward and downward, overlapping the edge of the scapula. The *cleithrum* lay on the outer side of the posterior end of the clavicle.

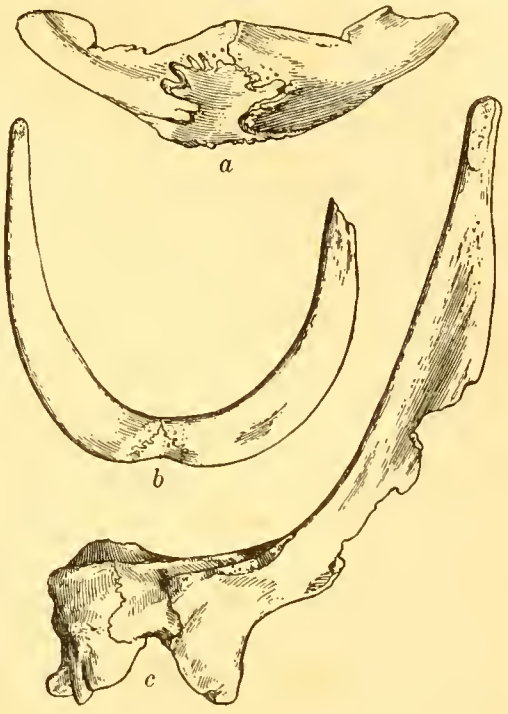


FIG. 26.—Anterior view of the clavicles and interclavicle of *Diadectes* sp. ×⅓. *a*, No. 4390 Am. Mus.; *b*, No. 1075 Univ. of Chicago; *c*, No. 4771 Am. Mus.

There are specimens of clavicles and interclavicles which are so different from those of the more complete skeletons that they might serve as the basis of new species or genera were it advisable to establish new forms on such fragmentary material. One of these (No. 4390 Am. Mus. Nat. Hist. Cope Coll.) shows the clavicles with about the same relative curvature and included space as those described above, but there is not the deep notch on the lower face of the interclavicle.

Another specimen (No. 4771 Am. Mus. Nat. Hist. Cope Coll.) belongs to a much larger animal. The clavicles are more gently curved and there is a much wider space between them. There is no evidence of distortion due to pressure, but it may be that this is responsible for the lesser curvature. As the clavicle of the left side only is present, the matter must remain in doubt.

The *scapula* (plate 5, fig. 1, and text fig. 27) is as shown in figures. The coracoid and procoracoid are not separated from the scapula by suture. The posterior end terminates in a point formed by a slight excavation of the upper border.

A separate specimen consisting of the scapula and humerus of the left side only (No. 4709 Am. Mus. Nat. Hist.) and belonging to a large species of the genus permits of the best description. The anterior edge is nearly straight and shows the attachment of a cartilaginous epicoracoid of considerable size. On the superior

edge there is a notch near the anterior end, and just posterior to this, at the point where the clavicle would overlap the bone, there is a thickening of the edge. The posterior portion of the upper edge is straight or slightly concave. As in all other specimens no sutures can be traced between the scapula, coracoid, and procoracoid. The coracoid foramen penetrates the bone just anterior to the upper end of the cotylus. This latter is deep and obliquely placed, so that when it was in position it held the humerus almost at right angles to the scapula and limited it to a simple forward and back motion.

The *cleithrum* is best described from the same specimen as the scapula. It was closely applied to the posterior half of the upper edge of the scapula, the anterior half being deeply grooved on the lower surface to accommodate the upper edge of scapula. The posterior half is wider and thinner.

The *humerus* (plate 5, fig. 2; plate 6, figs, 7, 8, 9) is remarkable for its shortness and strength. The two ends are flattened and extended almost at right angles to

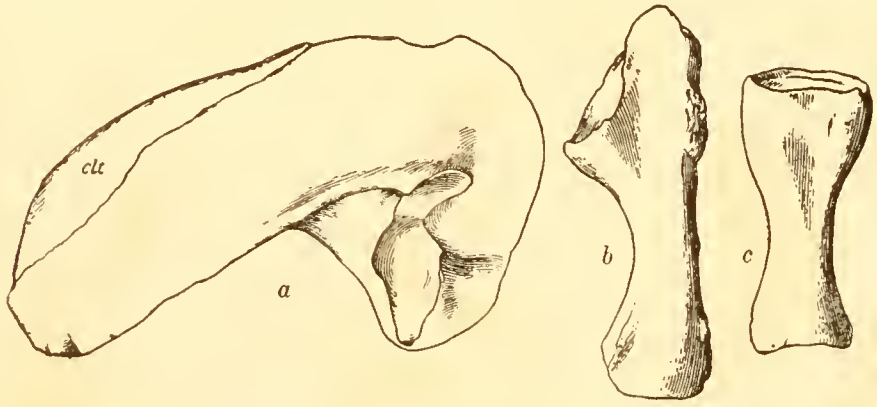


FIG. 27.—*Diadectes phaseolinus*. × ⅓. No. 4684 Am. Mus.
a, right scapula and cleithrum; *b*, ulna; *c*, radius.

each other; there is practically no shaft, the two ends joining directly. The proximal articular face lies obliquely across the proximal end; its limits are well defined, indicating little cartilage in the joint. The great deltoid ridge lies on the lower edge of the proximal end when the bone is in position. Just distal to the deltoid ridge (fig. 28) on the posterior edge of the bone, is a prominent ectepicondylar process; this stands straight out from the bone and does not curve downward, as in some reptiles, to form an ectepicondylar notch. The entepicondylar process is particularly broad and strong, being equaled in this respect only by the stegocephalians *Eryops* and *Stereorhachis*. At the inner distal corner of this process is a large pit for the attachment of a strong ligament. The entepicondylar foramen is an elongate oval. The articular surface for the head of the radius is a perfectly hemispherical surface on the anterior face of the bone. The face for the ulna is largely confined to the distal end.

Radius: The shaft is nearly straight. The upper articular face is roundly triangular and the lower face is more of an elongate oval; this is partly due to crushing (fig. 27, *c*).

Ulna: The proximal end has an oblique articular face, but there is not a well-formed sigmoid cavity to fit closely around the end of the humerus, as in the Pelycosaurs; it resembles much more closely the ulna of the amphibian *Eryops*. The articular face curves over the upper end of the bone until it appears slightly on the posterior surface. The shaft is a narrow oval in section. The distal articular

face is curved and directed largely toward the inner side of the bone. The whole bone is much more clumsy and ill formed than that of the Pelycosaurs (fig. 27, *b*).

The *pelvis* (plate 7, fig. 7) is somewhat distorted by pressure in No. 4684 Am. Mus., and the description is taken largely from No. 1075 Univ. Chicago. The *ischium* and *pubis* are broad, flat plates lying horizontally in the body; they are closely united with each other and with the bones of the opposite side. The symphysis is marked by a rather prominent but low keel (fig. 29, *A* and *C*). It is thicker than it appears on the outer surface, for the contiguous portions of the pubes and ischia of the two sides are much swollen, but the thickening due to this is largely shown on the upper surface. This condition is best shown in specimen No. 4848 Am. Mus., fig. 29, *B*. The anterior edge of the pubis is much broader than the posterior end of the ischium, so the pelvis is wider anteriorly. The exact position of the pubic foramen can not be determined.

The portions of the ischium and pubis concerned in the acetabulum stand almost at right angles to the rest of the bones, so that there is a prominent angle on

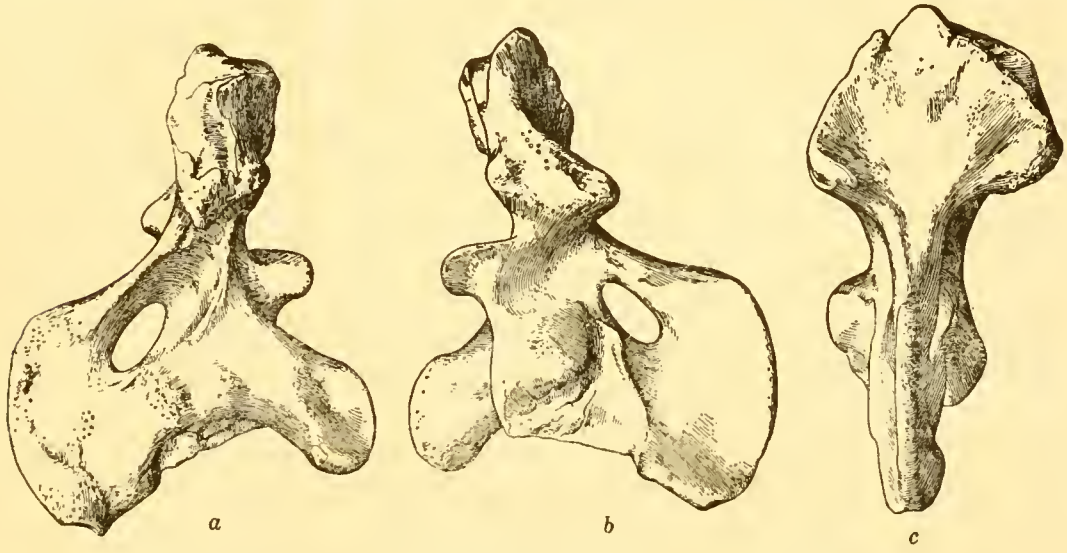


FIG. 28.—Three views of the right humerus of *Diadectes* sp. No. 4380 Am. Mus. × ½. *a*, posterior view; *b*, anterior; *c*, inner.

the outer side of the pelvis. The ilium rises almost vertically; the shaft is proportionally rather stout and the upper end thin and extended to the rear in a blunt point. In specimen No. 4684 the shaft remains quite thick nearly to the upper end and then is suddenly pinched in forming a sort of shelf strongly suggestive of the attachment of a plate over the ilium, but no trace of any such plate has been found.

The cavity of the pelvis looks particularly narrow and Pelycosaur-like in the mounted specimen, No. 4684 Am. Mus., but this is largely due to crushing. Specimen No. 4373 Am. Mus. shows a pelvis that has been preserved without distortion of the cavity (see plate 9).

A pelvis in the museum of the Alte Akademie in Munich shows a distinct facet for a prepubis; this has not been noticed in any of the specimens in the American collections (see figure 6, plate XIII, in Broili (5).

The *femur* (plate 6, figs. 4 and 5) resembles that of *Dimetrodon*, but, as in all the limb bones, it is shorter, stronger, and more clumsy of build. The articular face of the proximal end is nearly flat; it covers the end and descends somewhat on the outer surface. The anterior face of the upper end is concave and the inner

edge extends downward and outward on to the shaft of the bone and forms a prominent tuberosity near the lower edge of the concave space; from this point a low ridge is continued on the posterior surface of the shaft until it disappears near the middle of the bone. The articular face of the distal end has two parts; the inner is double, being nearly divided by a notch on the anterior edge, which corresponds to the groove on the anterior surface of the upper end of the tibia. The outer face is elongated

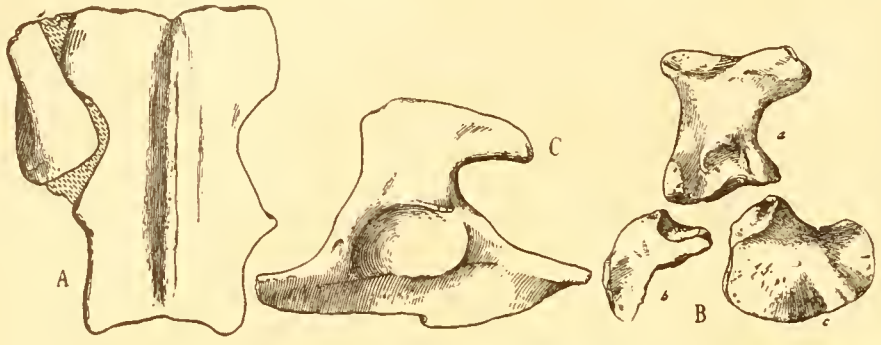


FIG. 29.

A. Lower view of pelvis of *Diadectes* sp. × ½. No. 1075 Univ. of Chicago.
B. Pelvis of an unknown Diadectid. × ½. No. 4848 Am. Mus. *a*, ilium; *b*, pubis; *c*, ischium.
C. Right side of pelvis of *Diadectes* sp. × ½. No. 1075 Univ. of Chicago.

at right angles to the head of the tibia and nearly separated from it. It supports the fibula.

The *tibia* is short with an especially heavy proximal end. This is partly divided into two faces by a deep groove on the anterior face, to correspond with the two faces of the femur. The distal articular face is inclined obliquely upward and inward and is slightly crescentic in outline (fig. 30, *b* and *c*).

The *fibula* in known specimens is crushed flat; it was probably fairly flat in the natural condition. The upper end is thin and wide, but less so than the distal. It was probably concave on the inner side to fit around the edge of the tibia. The distal face is set obliquely in opposition to the distal face of the tibia (fig. 30, *d*).

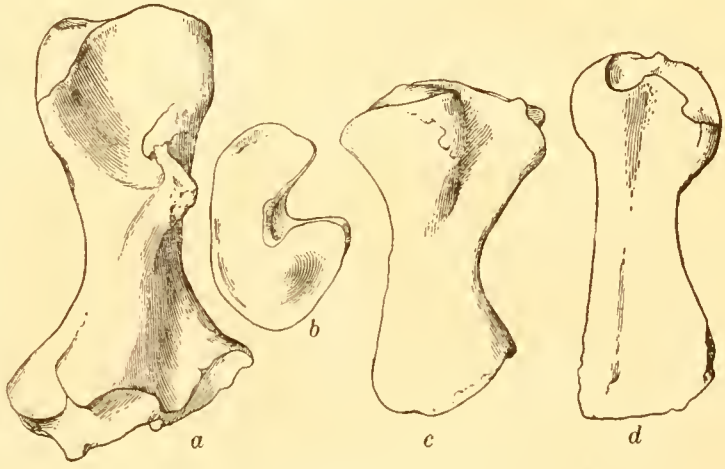


FIG. 30.—*Diadectes phaseolinus*. × ½. No. 4684 Am. Mus.
a, Posterior surface of the right femur; *b*, upper articular surface of tibia; *c*, anterior view of left tibia; *d*, fibula.

The *feet* (plate 7, fig. 1) are unfortunately very poorly known; no specimen has been found with any portion of the feet in position. The figures show that all the bones were stout and heavy and that the foot must have been very broad. The metapodials are heavy and the phalanges very short. The number of phalanges is uncertain, but even if the animal is given the primitive reptilian number, 2, 3, 4, 5, 4, such as Broom gives *Pareiasaurus*, or 2, 3, 3, 4, 3, as occurs in the specimen of *Pareiasaurus* in British Museum and in

Captorhinus isolomus (*Pariotichus laticeps*, *vide* Williston), the foot remains very short. The terminal phalanges are broad and spatulate, with thin and very rugose edges, indicating the attachment of a heavy nail.

FIG. 31.—Bones of the foot of *Diadectes* sp. No. 4381 Am. Mus. × ⅓.
a, calcaneum; *b*, astragalus.

Measurements.

No. 4684 Am. Mus.	mm
Length of lower jaw	195.5
Length of scapula	308
Breadth of scapula at cotylus	175
Length of clavicle	209
Length of humerus	181
Breadth of humerus, proximal end	95.5
Breadth of humerus, distal end	123
Length of radius	108
Breadth of radius, proximal end	41
Breadth of radius, distal end	53
Length of ulna	157
Length of pubis and ischium	203
Length of symphysis	155

No. 4684 Am. Mus.	mm
Width across pubes at anterior end	152
Length of femur	190
Breadth of femur, proximal end	73.5
Breadth of femur distal end	107.5
Length of tibia	130
Breadth of tibia, proximal end.	82
Breadth of tibia, distal end.	57
Length of ulna	135
Breadth of ulna, proximal end	60
Breadth of ulna, distal end	58
Breadth across fore foot as mounted	143
Length of longest digit	130
Assumed length of carpus	75
Approximate length of sixth rib	328

Vertebræ, No. 4684 Am. Mus.

Dorsals.	Height.	Breadth across transverse processes.	Anteroposterior distance across zygapophyses.	Caudals.	Height.	Breadth at base of ribs.	Anteroposterior distance across zygapophyses.
	mm	*mm*	*mm*		*mm*	*mm*	*mm*
3	97	92.5	42	1	129	67	49
5	98	92	46	6	125	58	42
9	105	106	54	10	85	35	42
13	119	119	54	15	62	23	30
18	148	83	63	25	30	13	25
21	159	68	59.5				

Scapula and humerus, No. 4709 Am. Mus.:	mm
Length of scapula	353
Width across cotylus	197
Length of cleithrum	251
Length of humerus	215
Width of proximal end of humerus	133
Width of distal end of incomplete humerus	130
Fragment of an enormous femur, crushed, No. 4361 Am. Mus.:	
Width across head	122.5

Leg bones and phalanges of a large specimen, No. 4381 Am. Mus.:	mm
Length of tibia	133.5
Length of largest ungual phalanx	29
Width of same	32.5
Another giant femur, crushed, No. 4379 Am. Mus.:	
Width of distal end	138.5
Length	261

RESTORATION OF DIADECTES PHASEOLINUS. (Plate 14.)

The restoration is based on the specimen No. 4684 Am. Mus., used as the basis of the foregoing description, but a few points are taken from other specimens. There are lacking from the specimen, the skull, axis, and atlas, many of the bones of the feet, and some of the caudal vertebræ. The teeth of the lower jaw show that the animal belongs to the same species, *phaseolinus*, as the skull No. 4839 Am. Mus., and this skull, which belonged to an animal only slightly smaller, was used in the restoration. The atlas and axis are restored from the individual No. 1075, in the collection of the University of Chicago. The feet are conjectural; the number of phalanges has been placed at the primitive formula 2, 3, 4, 5, 4–3, but it may be that the formula was more simple, perhaps the 2, 3, 3, 4, 3 suggested for *Pareiasaurus*. The number of vertebræ in the presacral series, as restored, is twenty-one, one more than in the complete series in the Chicago specimen, but there seems no escape from the conclusion that the first vertebra preserved is the third.

The general form impresses one with its peculiar massiveness and clumsiness, which is even more pronounced than that in *Pareiasaurus* as restored by Broom.* The head is heavy and was held low, just clearing the ground and probably frequently resting upon it. There was no neck, and the thoracic region was much more narrow than might have been expected. The limbs were very powerful, but exceedingly short, and as the motion of the humerus was closely limited to a forward and backward movement in the horizontal plane, the movement of the limbs must have been like that of the turtles. Viewed from the front, the heavy head and short limbs, with the humeri standing almost straight out from the scapulæ, give the animal a very testudinate appearance. The expanded thoracic ribs and the plates over the sixth, seventh, and eighth are in keeping with what seems to be a general tendency in adaptation during the period. Many of the herbivorous reptiles and amphibians show an expansion of the ribs with or without an accompaniment of overlying plates; this was perhaps an attempt to resist the attacks of such fiercely carnivorous forms as *Dimetrodon*, in a time before agility of body or high intelligence had become possible adaptations. No attempt has been made to represent a dorsal armor, but the character of the terminations of the neural spines, the numerous parallel adaptations with *Pareiasaurus* in which such plates occur, and the numerous instances of a dorsal armor in coexisting forms render it very probable that there was such a protection, at least in a rudimentary state.

The wide, short feet with the strong blunt nails suggest the land turtles more than any other type. The tail resembled that of the modern Crocodilia in form and proportions. In looking about for a modern reptile with which to compare it, *Heloderma* seemed the nearest in many respects. If the limbs of this lizard were shortened, the claws turned to nails, and the bulky tail fashioned into that of a crocodile the resemblance would be very exact.

The habits of the creature are at least indicated. Herbivorous, of low brain power, sluggish in action, it can only have occupied a purely defensive attitude towards such animals as the carnivorous Pelycosaurs. The strong girdles, powerful limbs with well-formed articulations and especially strong rugosities for muscular attachment, the closely knit and well-formed carpus and tarsus, all indicate a terrestrial habit. The broad, short feet, with large spatulate terminal phalanges which were covered by powerful nail-like claws, strongly resemble those of certain fossorial forms, such as the gopher turtle of Florida, *Gopherus polyphemus*. It seems probable that the foot rested fairly flat on the ground with a pad raising the

* Annals South African Museum, vol. IV, pt. II, 1903.

carpus and tarsus slightly. A small fragment of shale from the same region in which this specimen was found carries the impression of two feet of a smaller animal, but indicates that the foot was elevated, as only the impression of the claws and of a flat pad are shown.

I believe these animals to have been harmless, sluggish, terrestrial herbivores, possibly fossorial in habit, at least to the extent of excavating burrows for their protection. The attitude was habitually prone and they could not elevate the body on the limbs even so much as the Crocodilia, nor could they develop any speed even for short intervals.

PHYLOGENETIC POSITION.

The *Diadectosauria* have long been regarded as the nearest known form to the primitive ancestor of all the reptiles. This idea must be completely abandoned for the suborder. Aside from the extreme degree of specialization in all parts of the body, which shows how far it is from the primitive line, the structure of the skull makes it impossible that such types as double and single arched reptiles could have been derived therefrom, at least in the simple manner long believed. In fact, the greater our knowledge of these primitive forms becomes, the less certain are we of the primal origin of two great stems from a form with a complete roof. The Rhyncocephalian double-arch structure of the skull can not be derived from that of *Diadectes* or any other known Permian reptile which is not far too highly specialized in other characters to make its consideration worth while.

In a previous discussion of these forms (32) the author has suggested the possible ancestral relationship of the suborder *Diadectosauria* to the turtles. It is not assumed that this relationship is direct, but the specific resemblances, as well as the general effect of the mounted skeleton, indicate very strongly that they were not far from the ancestral form of the turtles. The specific points of resemblance as first stated are as follows:

I. The form and relations of the quadrate.
II. The degenerate palate and the disappearing transverse bone.
III. The absence of teeth on the palatines and pterygoids.
IV. The absence of a parasphenoid rostrum attached to the basisphenoid bone.
V. The absence of prevomers and the presence of an anteriorly placed single vomer (parasphenoid.)
VI. The method of entrance of the internal carotids into the brain cavity.
VII. The presence of paired descending plates from the roof of the skull anterior to the brain case.

Of these numbers, IV, V, and VI must be modified.

IV. Several specimens show no traces of an attached parasphenoid rostrum; this one, No. 4684 Am. Mus., shows a short and degenerate process. Versluys has recently brought evidence to show that *Dermochelys* has a distinct parasphenoid (36).
V. This is wrong. There is a separate parasphenoid (vomer) and distinct paired prevomers in the median line.
VI. In some specimens there are no foramina perforating the lower surface of the basisphenoid; in this there is a single large foramen.

The original conclusion seems still to be justified. Moreover, it will be at once seen how close is the resemblance of the squamosal and quadrate bones to the same elements in the turtles. If the quadratojugal and with it the quadrate foramen were to disappear, the condition of the turtles would be exactly realized; for in

the turtles the squamosal extends backwards overlying and surrounding the upper end of the quadrate. This is exactly the position of the squamosal or squamosal+tabulare in the *Diadectidæ:* the direct fusion of squamosal and tabulare would produce the condition of the testudinate squamosal

Diadectes molaris Cope . . . . (p. 15)
Diadectes biculminatus Cope . . (p. 17)
Diadectes fissus Cope . . . . . (p. 17)
Diadectes latibuccatus Cope . . . (p. 19)
Diadectes maximus Case . . . . (p. 20)
Diasparactus zenos Case . . . . (p. 21)

These species are all so incompletely known that an extended morphological discussion is impossible. The known facts are set forth in the systematic discussion.

Chilonyx rapidens Cope. (Plate 10, fig. 2.)

Characteristic specimen: The type, No. 4357 Am. Mus. Nat. Hist. Cope Coll. This genus probably held the same relation to *Diadectes* that *Geikia* did to *Pareiasaurus, Miolania* to other pleurodrian turtles, or that *Phrynosoma* does to related lizards. The development of bosses and bony horns is probably an expression of

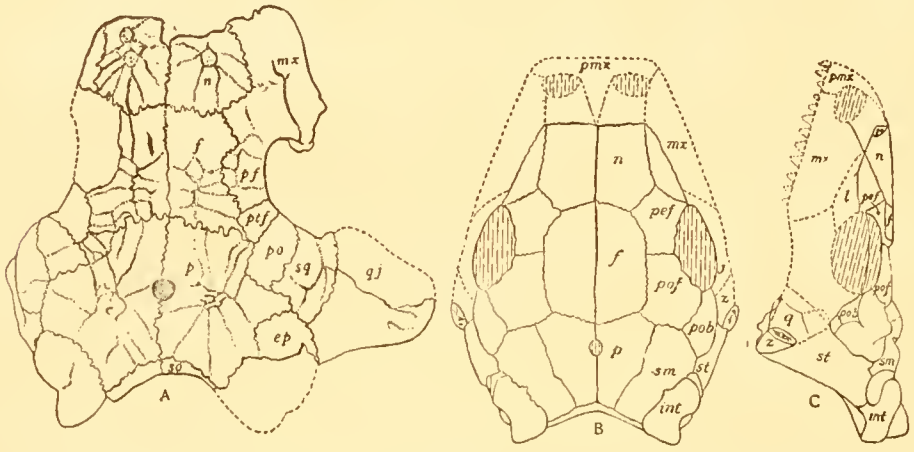


Fig. 32.

A. Upper surface of skull of *Chilonyx rapidens*. Sutures according to the author. × ¼. No. 4357 Am. Mus. *n*, nasal; *mx*, maxillary; *f*, frontal; *pf*, prefrontal; *ptf*, postfrontal; *po*, postorbital; *p*, parietal; *sq*, squamosal; *qj*, quadratojugal; *ep*, tabulare; *so*, supraoccipital plates.

B. Restoration of skull of *Chilonyx*, upper view. After Cope. *pmx*, premaxillary; *n*, nasal; *mx*, maxillary; *pef*, prefrontal; *pof*, postfrontal; *f*, frontal; *j*, jugal; *z*, zygomatic; *p*, parietal; *sm*, squamosal; *st*, prosquamosal; *int*, tabulare.

C. Restoration of skull of *Chilonyx*, lateral view. After Cope. *pmx*, premaxillary; *mx*, maxillary; *n*, nasal; *l*, lachrymal; *pef*, prefrontal; *f*, frontal; *pob*, postorbital; *pof*, postfrontal; *sm*, squamosal; *st*, prosquamosal; *int*, tabulare; *z*, zygomatic; *q*, quadrate.

the same force which led to the development of spines in *Naosaurus* and *Dimetrodon* and to similar extravagances in the Amphibia of the same beds. We have here a glimpse of overspecialization among the Diadectids, perhaps presaging their extinction.

In the original description of the genus (25) Cope writes as follows:

"The condition of the specimen is such that the composition of the skull may be readily made out. The postfrontal bones are large, and form the superior border of the orbit. At the front of the orbit they reach the prefrontal, thus excluding the frontal. The parietal bones are wider than the frontals, and are bounded laterally by the postfrontals and the squamosals and by an element between the squamosal and exoccipital, which occupies the position of the *intercalare* of the *Stegocephali*. Below this bone, on the inner side of the suspensorium, is the probable prootic. The squamosal, or an element which I can not distinguish from that bone, extends to the condyle of the quadrate, concealing that bone from external view. The

quadrate is short and thins out rapidly upwards, being closely united with the squamosal. Its condyle is set at an angle of 45° with the axis of the skull, and consists of one flat and one convex surface; continuous but forming a deep angle together. Exterior to the exoccipital, and interno-inferior to the intercalare, is a small distinct element, apparently in the position of an opisthotic or external occipital.

"The excavation for the auditory apparatus appears to be in the exoccipital. It is almost entirely filled by what I suppose to be a large stapes. This bone is in shape like a compressed flask, with the head directed inwards and forwards, and its inferior edge produced into a prominent keel, which is produced into a point below, and free from the neck of the flask. The head is truncate and is separated from the internal cranial wall by a narrow interspace. Its external extremity is not absolutely perfect in the specimen, but does not appear to have extended in an ossified condition beyond the exoccipital bone. In a specimen of *Empedias molaris** there is a meatus auditorius, in which the stapes was not found on cleaning out. This element is coosified with the surrounding bones laterally and posteriorly. Consequently when broken open, the vestibule is represented by two deep grooves, directed inwards and anteriorly."

In 1892 Cope (**35**) says:

"*Chilonyx* agrees with the *Stegocephalia* and with other *Diadectidæ* in possessing a distinct *intercalare* (*tabulare*). The component elements of the cranial roof are equal in number and similar in position to those of the *Stegocephalian* skull, except that the supramastoid (*squamosal*) extends between the parietal and *intercalare* (*tabulare*) to the posterior border of the cranial table; and the supraoccipital does not extend onto the superior face of the skull, except as a narrow border. The quadrate bone is directed forwards instead of posteriorly, which causes an anteroposterior abbreviation of the supratemporal and squamosal elements. The elements of the temporal roof are not exclusively tegumentary, but are identical in character with the bones of the brain case, and the sutures are visible on the under as well as the upper side."

In this paper he gave figures of the skull of *Chilonyx*. These figures were republished several times (**36, 42, 44**).

A comparison of Cope's figure with that worked out by the author, in collaboration with Dr. Broom, shows that the two interpretations do not agree. There are but two bones over the temporal region, not three; the condition is the same as in *Diadectes*, and *Chilonyx* can only be considered a very specialized genus of the same family. Cope's description of the posterior surface of the skull is erroneous, as is his figure of the quadrate region (plate VIII, fig. 6, Proc. Am. Phil. Soc., vol. XXXIV). It resembles in all respects the same region in *Diadectes*.

A single successional tooth just coming into place shows a single terminal cusp.

Bolbodon tenuitectus Cope. (Plate 10, fig. 1; text fig. 33, A.)

Characteristic specimen: The type, No. 4375 Am. Mus. Nat. Hist. Cope Coll. The sculpture of the skull is very much less rugose than that of *Diadectes phaseolinus*. The portion of the quadrate region preserved indicates that the tabulare is united with the squamosal, but as the sutures can not be made out this point is uncertain. The bone described by Cope as a turbinal is the same in position and relations as that described by Swinnerton and Howes in *Sphenodon* and by the author in *Dimetrodon* as a septo-maxillary. The bones described by Cope as palatines are the anterior ends of the prevomers. The molar teeth were apparently without cusps,

* Figured in Proc. Amer. Philos. Soc. vol. XIX, p. 56.

but all are badly worn and the fifth has apparently lost the apex since the original description. The tooth figured by Cope (43) is the last of the series and is of little diagnostic value, as the posterior teeth in all members of the family are of similar form.

Desmatodon hollandi Case. (Plate 8, figs. 2 and 3.)

Characteristic specimen: The type, No. 1938 Museum of Carnegie Institute. Aside from the teeth described as typical of this genus, there are several chevron bones belonging to an animal of larger size. Whether these belong to the genus *Desmatodon* is uncertain; they may indicate an animal more closely related to *Diadectes*, as they have the form and size of the chevrons of *Diadectes phaseolinus*. The largest one has a length of 51 mm.

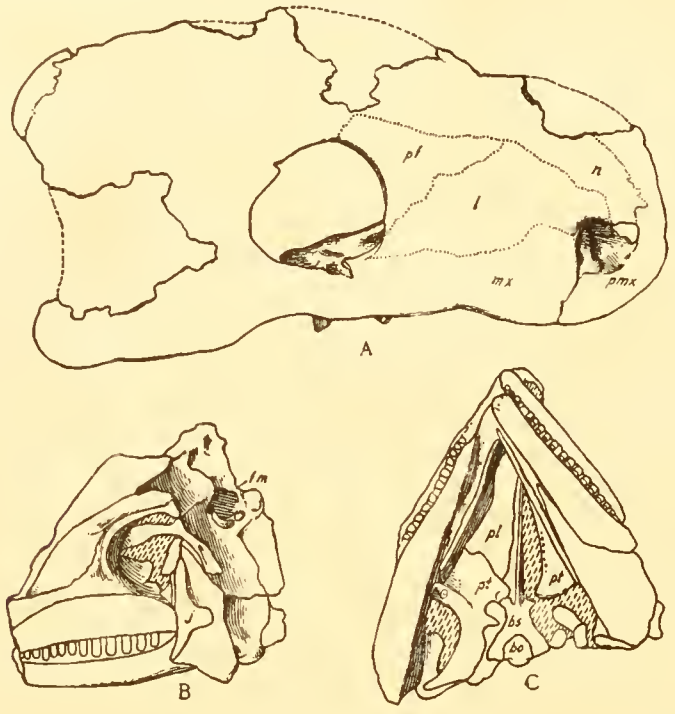


Fig. 33.

A. Lateral view of skull of *Bolbodon tenuitectus*. × ½. No. 4375 Am. Mus. *n*, nasal; *l*, lachrymal; *mx*, maxillary; *pmx*, premaxillary; *pf*, prefrontal.
B. Lateral view of skull of *Bolosaurus striatus*. × ⅔ No. 4686 Am. Mus. *fm*, foramen magnum; *j*, jugal.
C. Lower view of skull of *Bolosaurus striatus*. × ⅔. No. 4685 Am. Mus. *pl*, palatine; *pt*, pterygoid; *bs*, basisphenoid; *bo*, basioccipital.

The form of the teeth is intermediate between those of *Bolbodon* and *Diadectes*, as is shown in the accompanying figure (fig. 34). The various forms can not be regarded as phylogenetically connected, but represent different stages in an adaptation to a purely herbivorous diet.

These fossils are of peculiar interest because of the low geological horizon in which they were found. Mr. Raymond, the discoverer, writes of them as follows:

"The bones are from the upper part of the formation which I. C. White has named the Pittsburgh Red Shale (Geol. Survey West Virginia, vol. II, p. 263). This formation is usually from 100 to 125 feet thick in the vicinity and consists of red clays and red and yellow sandstones. At the top there is a bed of almost structureless clay, which varies from 18 to 40 feet in thickness. At Pitcairn the

clay is 37 feet thick and the fossils were found 4 feet above the base of the clay. Three feet above the base of the clay there is a layer of nodular limestone, and the teeth were found lying on this layer where it projects from the bank on the roadside. The other bones were all embedded in the clay, about one foot above the limestone * * *. On the Pittsburgh Shale rests the Ames Limestone, the youngest of the marine limestones in the region. It is almost exactly in the middle of the Conemaugh series. It is 315 feet below the base of the Pittsburgh Coal, and 695 feet below the base of the Dunkard series (Permian). The Ames Limestone is about 300 feet above the Freeport Coal (top of the Alleghany series)."

FIG. 34.—Outline drawings of several Diadectid teeth showing position of *Desmatodon*. *a*, *Bolbodon*; *b*, *Bolosaurus*; *c*, *Desmatodon*; *d*, *e*, *f*, *Diadectes*.

This is the lowest known horizon for reptiles except the locality of Linton, Jefferson County, Ohio (from which was described *Isodectes* Cope and *Eosauravus* Case), which is of Alleghany age.

Bolosaurus striatus Cope. (Plate 7, figs. 4, 5, 6.)

Characteristic specimens: Two skulls (Nos. 4685 and 4686) and several vertebræ (No. 4686) Am. Mus. Nat. Hist. A jaw, No. 4321 Am. Mus. Nat. Hist. Cope Coll.

The two skulls are in a good state of preservation except that one has been crushed from side to side and the other from above downward. I quote from a previous description (16):

"Unfortunately both specimens have been so injured in the temporal region that it is impossible to make out the limits of the individual bones, but there is no doubt that there was a complete roof without trace of temporal vacuities.

"The skull (fig. 33, *B* and *C*) was roughly triangular in form, wider and higher posteriorly, and terminating in a blunt snout anteriorly. The interorbital space is moderately wide and slightly concave or flat and is pierced by a fair-sized parietal foramen. The facial portion of the skull seems to have been rather sharply rounded above. The anterior end of the skull is so injured that it is not possible to determine the exact position of the nares, but they were nearly terminal and apparently looked outward rather than forward. The orbits are large and were nearly circular in outline; the anteroposterior diameter is nearly equal to the preorbital length of the skull. The edges of the orbit are prominent above and anteriorly, but are less so below; there is no pit in the prefrontal, such as is so characteristic of the *Pelycosauria*.

"From the condition of the specimen it is impossible to make out the shape or relations of all the bones, but it is evident that their surface was smooth and free from sculpture except along the anterior edge of the orbit.

"The *maxillary* is rather elevated with a convex superior edge and a nearly straight alveolar edge; posteriorly it extends almost to the back of the orbit but is prevented from taking any part in it by the jugal which overlies the posterior fourth. There are 16 counted teeth in the best-preserved specimen, which is evidently a nearly perfect premaxillary and maxillary series. The anterior three teeth, which probably belong to the premaxillary, are larger than the anterior maxillaries and probably functioned as incisors. In common with the anterior maxillaries they are simple cones with large pulp cavities. Beginning with the sixth tooth, the maxillary series increases in size to the tenth or eleventh, and then decreases in size to the posterior end; the last two are abruptly smaller and are only minute cones. The teeth from the sixth to the fourteenth show the characters of the family and genus. They are transversely expanded, much as in the *Diadectidæ*, but in a less degree, and on the outer edge there is a prominent cusp which descends considerably below

the rest of the crown. The apex of this cusp was originally sharp, but seems to have been worn blunt by attrition. The shape of these teeth indicates the assumption of an herbivorous habit and perhaps indicates the method of development of the Diadectid teeth.

"The exact outlines of the *frontals*, *nasals*, *prefrontals* and *lachrymals* can not be made out; the frontals were paired and took part in the upper edge of the orbit.

"The *jugal* is a long and slender bone which underlay the orbit and extended relatively far anterior and posterior to it; it did not extend upward to form a portion of the posterior edge, as in the *Pelycosauria*.

"The postorbital region is crushed in both specimens, but in them and in the type specimen it is evident that the region was covered by a complete roof without temporal vacuities. The form of the separate bones is obscure. The quadrate is a vertical plate and the articular surface has two condyles, elongate anteroposteriorly as in the *Diadectidæ*.

"The posterior surface of the skull is composed of a nearly vertical plate in which the sutures are mostly indistinguishable; the *exoccipital* is fused with the basioccipital and extended well up on the sides of the large and nearly circular foramen magnum. The occipital condyle is slightly oval and is marked by a pit showing the termination of the notochord. The *opisthotic* is separate from the exoccipital and extends out to the quadrate as a strong process. On either side of the posterior face of the skull there is a good-sized posttemporal vacuity. There is no trace of a foramen quadratum.

"The under surface of the skull is most interesting, showing the strong resemblance to the *Captorhinidæ* in the presence of the strong parasphenoid rostrum and the external process of the pterygoids, points in which it differs from the *Diadectidæ*. The *basisphenoid* is shaped much like that in the *Pelycosauria* and the *Captorhinidæ;* attached to the anterior end is a slender *parasphenoid rostrum*, which is of exceptional length; it extended far forward between the palatines. The posterior end is expanded and the lower surface is excavated by a shallow pit; near the anterior end are prominent basipterygoid processes which bear smooth articular faces. There is no trace of foramina for the external carotids on the lower surface, but these may be very obscure because of their minute size and the condition of the surface of the bone. In the specimen numbered 4685 the basioccipital has been pushed forward out of place and lies partly in the pit at the posterior end of the basisphenoid.

"The *pterygoid* has the tripartite form familiar in the *Pelycosauria* and the *Diadectidæ*. The anterior process extends forward and fuses with the palatine so intimately that the suture can not be made out; between the pterygoids and palatines of the two sides there is considerable space which is divided by the elongate parasphenoid rostrum; it is probable that the anterior end of the dividing plate is formed by the *vomer*. The external process of the pterygoid curves outward from the middle of the bone and presents a prominent vertical face to the inner side of the lower jaw. The lower edge of this process carries a row of prominent, bluntly conical teeth, set in sockets. There are six teeth in the best-preserved row with the base of a seventh set off to one side; the outer end of the row of teeth is bent sharply forward with the process.

"The *lower jaw* is very high posteriorly and becomes more slender anteriorly. The alveolar edge is nearly straight, as in the maxillary, and there are 13-14 counted teeth and alveoli; this series does not seem to be complete and there were probably one or two more. As in the upper jaw, there is no trace of enlarged canines and the teeth in the middle of the series are somewhat larger than those at the ends; the last two teeth are abruptly smaller. The teeth of the middle portion of the series

have a very similar appearance to those of the maxillary; the base of the crown is swollen and the inner edge is continued upward in a cone which was sharp originally, but it seems to be worn blunt by use. The articular region shows two cotyli for the condyles of the quadrate and is expanded laterally for their accommodation, as in the *Diadectidæ*. Though the posterior portion of the jaw is very high, there is no distinct coronoid process, and there are no vacuities in the outer surface of the jaw. The relations of the various bones can not all be made out, but it is evident that the splenial extends far forward and took part in the symphysis."

Measurements.

	mm		mm
Length of the lower jaw of No. 4685, perfect	31	Length of a caudal	17
Width across the posterior end of the skull	28	Width of distal end of a humerus	12
Length of three middorsals	23	Probable length of same, about	40

No specimens have been found with limb bones and vertebræ definitely in association with the skull. In one locality a considerable number of vertebræ and limb bones of the proper size were found with three skulls, but as this was in a bone bed and as there were bones of other animals mingled with them there can be no certainty that the skulls and limb bones belong together. Three vertebræ are shown in fig. 35, *a* and *b;* the vertebræ are all notochordal and vary considerably in form, from short and high dorsals to very elongate caudals. The dorsal vertebræ are short and wide, with wide zygapophyses and low neural spines; the transverse processes stand out at right angles from the sides of the centrum and the neural arch just below the anterior zygapophyses. The head of a small femur is without well-defined articular surface. The distal end, in a second specimen, shows that the femur was long and slender without well-defined entepicondylar or ectepicondylar processes. There is the usual entepicondylar foramen.

a *b*

Fig. 35.—Dorsal vertebræ of *Bolosaurus* (?). × ¾. No. 4686 Am. Mus. *a*, top view; *b*, lateral view.

A fragment of a pelvis, No. 4326 Am. Mus., shows that the ischium and pubis had the primitive broad and plate-like form. There seems to have been two sacrals.

The type specimen is in such poor condition that little detail can be made, but the teeth of the lower jaw show the characteristic form and permit the identification of other specimens.

Pariotichus brachyops Cope.

Characteristic specimen: A small skull, No. 4760, Am. Mus. Nat. Hist. The type specimen is in extremely poor condition and nothing can be made out concerning the arrangement of the bones of the skull or the condition of the surface. The maxillary teeth are fairly well preserved and from these the homotype has been identified. The type skull is similar in appearance to the small amphibian *Lysorophus*, but the teeth are totally unlike any amphibian from the Permian. On the lower surface is a single broad plate, the component elements of which can not be made out. It resembles the great parasphenoid of *Lysorophus*, but equally so the plate formed by the parasphenoid and basisphenoid in *Gymnarthrus*.

The homotype is in good preservation. This shows that the skull was low and the anterior end of the muzzle blunt. The orbits are large and circular and look laterally and a little upward. There is the same arrangement of the bones of the temporal region as in the *Captorhinidæ;* that is, there are but two bones over the temporal region. The supraoccipital plates are vertical at the back of the skull.

The arrangement is shown in fig. 36, *C* and *D*. The teeth are bluntly conical with no anteroposterior cutting edges. The enlarged tooth is near the anterior end of the maxillary series. There are no enlarged teeth in the lower jaw, and in neither jaw can any trace of more than one row be made, but this is inconclusive, as such teeth would be covered if present.

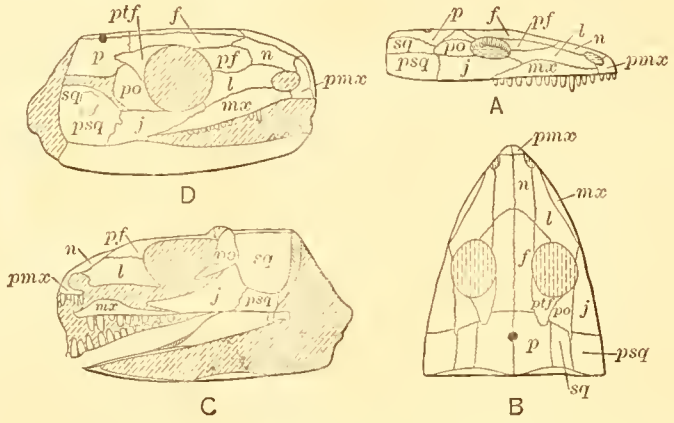


FIG. 36.—*Pariotichus brachyops*. No. 4760. Am. Mus.

A. Lateral restoration of skull. × ⅔. *pmx*, premaxillary; *mx*, maxillary; *n*, nasal; *l*, lachrymal; *pf*, prefrontal; *j*, jugal; *f*, frontal; *po*, postorbital; *p*, parietal; *sq*, squamosal; *psq*, prosquamosal.
B. Restoration of upper surface of skull. × ⅔. Lettering as in A.
C. Left side of same specimen as shown in D.
D. Lateral view of skull. × ⅔. Lettering as in A.

There is no resemblance between these skulls and those of the genus *Captorhinus*, though most of the skulls of the latter genus were originally described as *Pariotichus*. As they form a distinct and separate group they have been placed together in a separate family, *Captorhinidæ*.

Measurements.

	mm
Length of the type skull	22
Width of same at back	22
Length of skull of homotype	20.5
Width at back	14

Isodectes megalops Cope.

Characteristic specimen: A small skull, No. 4329 Am. Mus. Nat. Hist. Cope Coll. The skull is fairly well preserved and shows a fine reticulate sculpture. No palatine teeth can be made out and the teeth on the premaxillary and the anterior

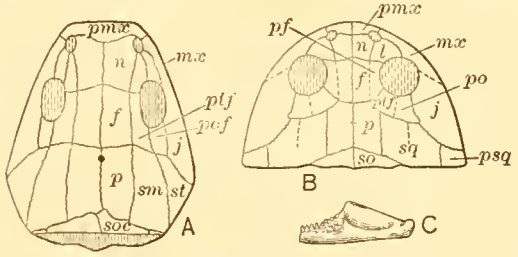


FIG. 37.—*Isodectes* sp.

A. Upper view of skull. *pmx*, premaxillary; *mx*, maxillary; *n*, nasal; *f*, frontal; *ptf*, postfrontal; *pot*, postorbital; *p*, parietal; *j*, jugal; *sm*, squamosal; *st*, prosquamosal; *soc*, supraoccipital plates. After Cope.
B. Restoration of skull according to the author. × ⅓ This restoration shows the skull too wide, as the bones have been placed to show their full width. Lettering as in previous figures.
C. Lower jaw, showing numerous teeth. × ½.

part of the maxillary are more sharply conical than those on the lower jaw. The lower jaw has a prominent coronoid process and just anterior to this the dentary is widened and there is a patch of small blunt teeth. They are partly obscured by the matrix, so that the exact position can not be made out, but they seem to be irregularly arranged; in the anterior portion of the jaw is a single row of teeth. The

appearance of the teeth does not warrant the description given by Cope in his analytical table of the genera of the *Captorhinidæ* (*Parioticlidæ*). He says the palatal and splenial teeth are compressed and that the jaw teeth are equal and acute. No splenial or palatine teeth can be seen and the condition of the specimen does not show that the jaw teeth are equal; there was at least one elongated tooth in the anterior part of the maxillary series.

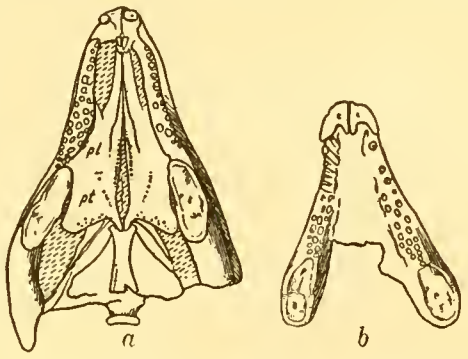


FIG. 38.—*Captorhinus aguti*. × ⅓. No. 4334 Am. Mus. *a*, Lower view of skull; *b*, lower jaw. The posterior ends of the lower jaws are attached to the skull. *pl*, palatine; *pt*, pterygoid.

Genus CAPTORHINUS Cope. (Plate 11, figs. 1. 2, 3.)

Characteristic specimens: Nos. 4334, 4328, 4424, all Am. Mus. Nat. Hist. Cope Coll.; No. 642, University of Chicago.

The following description of the genus is based on all the specimens, as the specific differences are minor and, as stated before, even of doubtful value in one or two cases. The best-preserved specimen of the skull is that described by Cope as *Pariotichus aguti*, No. 4334 Am. Mus. This has also the clavicles and interclavicle, the humerus of the right side, and the first few vertebræ.

The general shape of the skull, as described by Cope, is elongate, flat on the top, with a decurved snout and a wide temporal region.

Premaxillaries: These are small and hardly appear on the upper surface of the skull; each one carries four teeth. The median pair is the largest, the others diminishing rapidly and regularly to the maxillary-premaxillary suture.

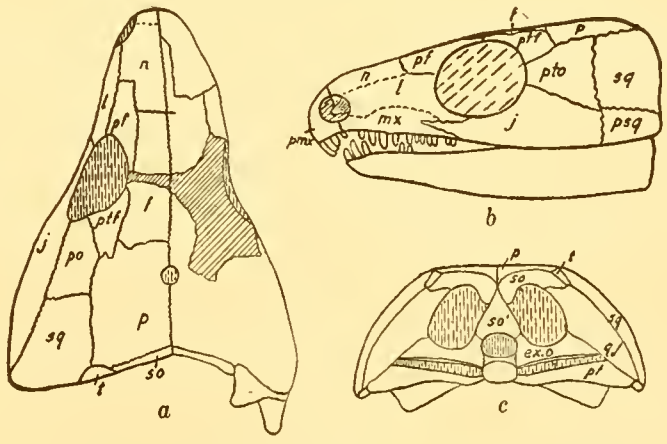


FIG. 39.—*Captorhinus angusticeps*. × ⅔. No. 4457 Am. Mus.

a. Upper view of skull. *n*, nasal; *l*, lachrymal; *ptf*, postfrontal; *pf*, prefrontal; *po*, postorbital; *f*, frontal; *j*, jugal; *sq*, squamosal; *p*, parietal; *so*, supraoccipital plate; *t*, tabulare.

b. Lateral view of same specimen shown in *a*.

c. Posterior surface of skull. *p*, parietal; *t*, tabulare; *so*, supraoccipital plate; *so'*, supraoccipital; *exo*, exoccipital; *qj*, quadratojugal; *sq*, squamosal; *pt*, pterygoid.

The *nasals* are large bones reaching back nearly to the anterior edge of the orbit and forming the inner edge of the nares.

The *lachrymals* form the anterior border of the orbit and reach forward to the nares, forming its posterior border.

The *prefrontals* form the upper anterior border of the orbit and lie between

frontals, nasals, and lachrymals. They meet, or very nearly meet, the postfrontals behind, so that the frontals take little if any part in the upper edge of the orbit.

The *frontals* reach nearly or quite from orbit to orbit and extend an equal distance anterior and posterior to them. This portion of the skull is flat or slightly concave.

The *parietals* are wide, extending beyond the frontals; the parietal foramen lies in the anterior third. The posterior edge of the parietal is separated from the posterior border of the skull by the upper edge of the vertical supraoccipital plates.

The *postfrontals* are small triangular bones, forming the posterior half of the upper edge of the orbits and a part of the posterior edge.

The *postorbitals* are nearly square; they form the greater portion of the posterior edge of the orbit.

The *jugal* is elongate, extending from the anterior edge of the orbit almost to the posterior end of the skull. It is quite high in the middle, and forms with the postorbital the posterior rim of the orbit.

The *squamosals:* On either side of the parietal are two bones which form the posterior part of the temporal roof. The upper of these, occupying the position of the squamosal, is rather longer than broad and extends as far forwards as the parie-

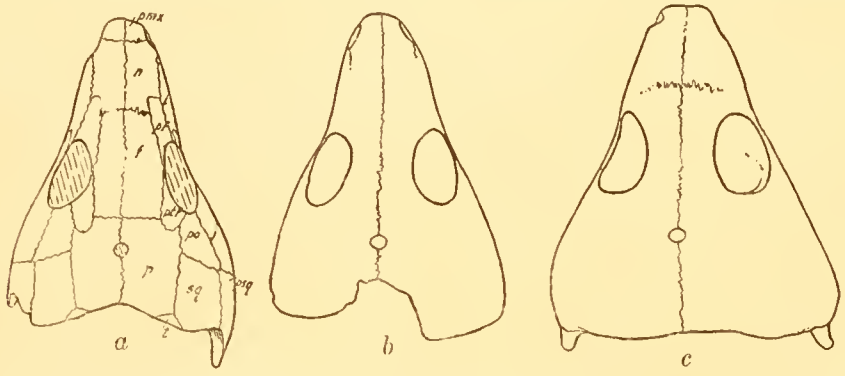


Fig. 40.—*a*. Upper view of skull of *Captorhinus isolomus*. × ⅔. No. 4338 Am. Mus. Lettering as in fig. 39.
b. Upper view of skull of *C. aguti*. × ⅔. No. 4334 Am. Mus.
c. Upper view of skull of *C. aguti*. × ⅔. No. 4338 Am. Mus.

tal foramen. Below this is a larger bone which articulates with the postfrontal, postorbital, and jugal; its posterior edge forms the edge of the skull and covers the quadrate; it is regarded as the *prosquamosal* for the following reasons:

The *posterior surface* (fig. 39, *c*) of the skull is formed above by a pair of plates on either side, lying at right angles to the bones of the surface. The inner bones are the *supraoccipital plates;* they meet in the median line and extend downward, probably forming the upper edge of the foramen magnum. The outer end terminates in a point which is wedged in between the squamosal and the second plate on the posterior surface. This plate is abruptly wider than the supraoccipital and extends down to the posterior angle of the skull, completely covering the quadrate behind. Between the exoccipital and the second plates on each side is the large posttemporal fenestra. The outer pair of plates is homologous with the bone identified in the Pelycosaurs as the quadratojugal.

A small triangular element lying between the supraoccipital plate, the squamosal, and the quadratojugal is the last trace of the *tabulare*, as suggested by Cope.

With the recognition that the temporal region is covered in the *Diadectidæ*, *Pariotichidæ*, and *Captorhinidæ* by only two elements instead of three, as in the

typical Stegocephalian skull, comes not only the recognition that these forms can not be the primitive stem groups of the reptilia but also the serious morphological question of the homology of the bones. Is the lower bone of the two covering the temporal region and connecting the quadrate with the jugal, the quadratojugal of higher Reptilia or is it the prosquamosal? In *Dimetrodon* there is a single plate on the posterior side of the quadrate, connecting with the postorbital above and partially separated from the quadrate below by a quadrate foramen. This bone I have called the quadratojugal, and the bone which connects it with the jugal I have designated as the prosquamosal (16). This nomenclature is quite different from that usually accepted and several objections have been urged against it. Notably, that the paroccipital (opisthotic) comes in contact with the bone called quadratojugal, which is not common among recent reptiles, and that the second bone should not be called prosquamosal, because the name quadratojugal has commonly been applied to the element connecting the quadrate with the jugal. These objections have been partially replied to and the arguments, somewhat amplified, are repeated here.

In the first place it must be clearly recognized that: (1) The Rhyncocephalian skull can not be regarded as a stem form from which all other reptilian two-arched types were derived; (2) the Rhyncocephalian skull can not be derived simply and directly from the Cotylosaurian skull; (3) the Cotylosaurian skull can not be regarded as the single primitive type of reptilian skull. If we free our minds of these conceptions, so long dominant in the theory of the development of the reptiles, the questions are less difficult.

The first objection to designating as the quadratojugal the element which covers the quadrate posteriorly and is separated from it in the Pelycosaurs and *Diadectidæ* by a quadrate foramen, is that it comes in contact with the paroccipital in *Labidosaurus* and probably in *Captorhinus*, *Diadectes*, and the *Pelycosauria* also. This objection is not vital, for such a condition occurs in the dinosaurs *Allosaurus* and *Tyrannosaurus*, where the element (quadratojugal) comes directly in contact with the jugal anteriorly and is unquestionably a quadratojugal; in other respects it is almost exactly the same as in the Pelycosaurs and morphologically the same as in *Captorhinus*, with the possible exception of the lack of a quadrate foramen in that genus.

It will be seen that the bones on the posterior surface of the skull in *Captorhinus* and *Labidosaurus* have essentially the same arrangement as in *Dimetrodon;* in the latter genus the cartilaginous supraoccipital has developed, and the need for the dermal supraoccipital plates having passed they have disappeared. This process can be seen in *Labidosaurus*, where both the cartilaginous supraoccipital bone and the dermal supraoccipital plates are present. When the supraoccipital plates disappeared the parietal became the posterior bone on the upper surface of the skull and the squamosals became the posterior elements on the sides of the skull; the tabulare is just disappearing in *Captorhinus* and is completely lost in *Labidosaurus*, the Pelycosaurs, and the *Diadectidæ* (?). The squamosals would now have the same relation to the upper end of the bones lying on the posterior face of the quadrate that the supraoccipital plates did in the *Cotylosauria*.

There is no inherent improbability that the element connecting the quadrate with the jugal is the prosquamosal (supratemporal); indeed if the arguments offered above have weight, it must be by exclusion. Other facts, however, may be cited in favor of this idea. The temporal region in the *Stegocephalia* is covered by the parietal, squamosal, prosquamosal, quadratojugal, and jugal. The prosquamosal is commonly the largest element of the temporal region; it articulates with the postorbital anteriorly below, and in many forms, as *Branchiosaurus*, etc., pos-

teriorly, with the quadratojugal; it overlies the quadrate. The quadratojugal lies on the outer side of the quadrate and frequently extends up behind it; the portion which extends up behind the quadrate articulates with the posterior edge of the prosquamosal. This is exactly the relation of the outer pair of posterior elements in *Captorhinus* and the *Pelycosauria*.

If we assume that this element covering the posterior and outer surface of the quadrate in *Captorhinus*, *Diadectes*, and the *Pelycosauria*, and separated from the quadrate by a foramen, is, in the last two, the quadratojugal, then we have in the temporal region the full number of bones of the Stegocephalian skull; this bone is in many forms, where it articulates directly with the jugal (*Rhyncocephalia*, Theropodus Dinosaurs, and Phytosaurs), unhesitatingly called the quadratojugal. If, on the other hand, we assume this bone to be a new element and the bone anterior to it, in Pelycosaurs and Cotylosaurs, to be the quadratojugal, the skulls are radically different from the Stegocephalian skulls, having one more element on the posterior surface of the skull and one less in the temporal region.

The condition of the Pelycosaurian skull gives a hint as to the condition of the skull of *Sphenodon*. Baur claimed that in *Sphenodon* the squamosal and prosquamosal had united in a single element, but Swinnerton and Howse found no trace of any division of this element in even the youngest embryos. Is it not just as probable that the prosquamosal dropped down to the lower edge of the skull and formed the connecting link between the jugal and quadratojugal as that it rose and fused with the squamosal? In *Paleohatteria* the jugal joins the quadrate direct,* but the squamosal (prosquamosal?) projects down nearly between them. The quadratojugal, if present, was on the back of the skull.

As the *Cotylosauria* can no longer be considered as the primitive reptilian type, and as the *Rhyncocephalia* can no longer be considered as derived from them by the simple development of openings, the necessity of finding a prosquamosal bone in the skull of the *Rhyncocephalia* has passed.

The more definitely the anatomy of the primitive reptiles is known, the more apparent it becomes that the theory which places the *Rhyncocephalia* as a central type directly derived from the *Cotylosauria* and giving rise to two main branches of Reptilia is inadequate and must undergo a serious re-examination.

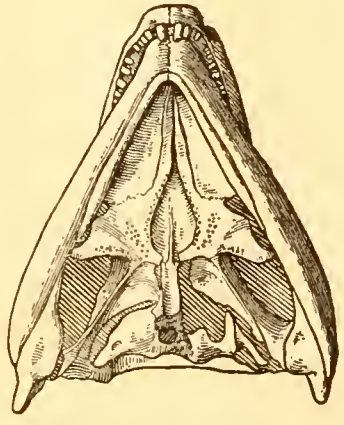


FIG. 41.—Lower view of skull of *C. isolomus*. × ¾. No. 4338 Am. Mus.

The *maxillary* does not have a great vertical extent, in any place, and beneath the orbit it is very slender. Thirteen bluntly conical teeth may be counted in the outer row, of which the fourth is the largest. Just posterior to the enlarged tooth the alveolar edge widens and there are three rows of irregularly placed teeth, the inner is the shorter and the outer the longer, so arranged that the whole patch is slightly crescent-shaped. These teeth are frequently so worn that they appear as flat-topped pegs rather than as blunt cones.

The *septomaxillary* bones (turbinate bones of Cope) are small elements appearing at the surface in the lower inner corner of the nares.

The lower surface of the skull: The *prevomers* are long and slender, meeting in the median line and inclosing anteriorly the posterior ends of the premaxillaries;

* Credner, Zeitsch. deutsch. geol. Gesell. Jahrg. 1888, 3, 546.

posteriorly they diverge and receive between them the anterior ends of the pterygoids. There is no trace of teeth on the prevomers. On either side are the elongate, oval openings of the posterior nares.

The *palatines* lie in the normal position, but the sutures can not be clearly made out; the posterior end seems to be marked by a suture extending inward and backward from a point about opposite the middle of the orbit. A short row of small teeth extending outward and forward from the median vacuity seems to be confined to the palatine.

The *pterygoids* have the usual tripartite form. The posterior process is a thin, nearly vertical, plate extending back to the quadrate and is applied to its inner surface. A strong basisphenoid process joins the basipterygoid process of the basisphenoid. In the type specimen of *C. aguti* the palate has been very slightly crushed together from the sides, so that the basisphenoid processes lie between the basipterygoid processes of the basisphenoid and the interpterygoid vacuity is narrowed. This may also account for the loss of the parasphenoid rostrum in this specimen. The external processes of the pterygoid extend out to the maxillary and there is no trace of an ectopterygoid bone. The posterior edge of the external process is prominent and the outer end is lower and presents a terminal face to the lower jaw, as in the *Crocodilia*, *Sphenodon*, and the *Pelycosauria*. The outer portion of this process supported a small cluster of minute teeth. The anterior processes are long and slender and extend far forward between the palatines and prevomers. The inner edges anterior to the basisphenoid processes are concave and surround a considerable interpterygoid vacuity; opposite the anterior end of the orbit the inner edges of the pterygoids come in contact. From a point opposite the palatine suture the inner edge of the pterygoid supports a single row of small teeth.

The *basisphenoid* is exceptionally elongate, with a deep groove on the ventral surface. The presence of foramina for the internal carotid arteries can not be made out.

The *paroccipital* is distinct and extends out to the quadrate; as in *Labidosaurus*, it comes in contact with the outer of the two vertical plates on the posterior surface of the skull, the quadratojugal.

The *lower jaw* shows the angular, surangular, splenial, and dentary; the other bones are not visible in any of the specimens. The *dentary* supports a cluster of teeth arranged in three irregular rows. The teeth are obtusely conical, as in the upper jaw. The anterior teeth are concealed by the overhanging maxillary in the type specimen of *C. aguti*, but in others it is seen that the first three were considerably larger than the others. The third is especially large and fits into the notch formed on the upper series by the reduction of the posterior premaxillaries and the anterior maxillaries. The *splenial* passes forward and takes a strong part in the symphysis. The *angular* and *surangular* extend back of the articular region and form a strong pointed projection at the rear of the jaw.

The *interclavicle* has a broad rhomboid head with a slender posterior prolongation; the end of this is broken away, so that it is impossible to give the exact length.

The *clavicles* have flat anterior ends lying upon the interclavicle and expanded parallel to it; the distal ends are expanded, but at a right angle to the proximal ends, so that while the proximal end was horizontal the distal end was vertical.

The *scapulæ* have not been made out sufficiently to give a figure. Williston (**67**) in his description of *Captorhinus isolomus* (*P. laticeps*) speaks of the shoulder girdle as follows: "It is very certain that the girdle was attached immediately back of the skull, the front part underlying the occipital condyle even. Its structure is almost identical with that of *Labidosaurus*, as figured by me (see fig. 47, *c*). I find

no indications of a cleithrum. It is very evident that the coracoids in life were in immediate contact along the median line, covered over by the prolongation of the interclavicle. The scapulæ curve upward at an angle of about forty-four degrees from the plane of the coracoids. Possibly this angle has been slightly reduced by pressure, but I think not. The scapulæ are directed, not backward, as has been supposed, but obliquely upward."

The *vertebral column:* In No. 4424 American Museum there are 25 presacrals. Between the twentieth and twenty-first there is a break, as the anterior portion of the twenty-first is lost; so there is some possibility that the number was greater, but this is very improbable. Williston gives twenty-three or twenty-four in his specimen No. 642 Univ. of Chicago, but the anterior cervicals are covered by the skull and there is a break near the sacrum, so that his number is also uncertain.

The *atlas* is unknown.

The *axis* does not seem to have been very different from the succeeding vertebræ. The spine was elongate anteroposteriorly, but not high. As all the vertebræ bear ribs and are strikingly similar in form it is impossible to divide the column into

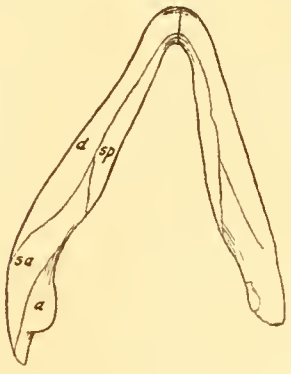


FIG. 42.—Lower jaw of *C. angusticeps*. × ¾. No. 4456 Am. Mus. *d*, dentary; *sp*, splenial; *sa*, surangular; *a*, articular

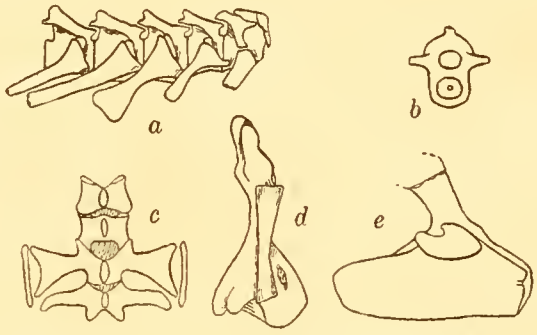


FIG. 43.—*Captorhinus*. × ½. No. 4424 Am. Mus. *a*, cervical vertebræ; *b*, cross-section of a dorsal vertebra; *c*, sacral vertebræ; *d*, humerus and radius; *e*, left side of pelvis.

cervical, dorsal, and lumbar regions. All the vertebræ have low, rounded neural arches, with wide zygapophyses. The anteroposterior and transverse diameters of the neural arches are nearly equal. The transverse processes of the anterior vertebræ originate high up on the centrum and the side of the neural arch and stand out almost at right angles. The articular face for the rib is elongate vertically; the lower edge is attached near to the anterior edge of the centrum and is close to it, so the face slants forward and inward, as in *Diadectes* and *Labidosaurus*. In the posterior vertebræ the transverse processes are more slender and rod-like and originate high up on the centrum. The body of the centrum is contracted slightly in the middle portion, but there are no keels or ridges. Small intercentra were present throughout the column.

There are two *sacral vertebræ*. The first has a large rib expanded distally and directed straight out to the ilium. The second sacral is much smaller and its rib appears to be very largely applied to the posterior surface of the distal half of the anterior sacral rib.

The *caudal vertebræ* have more slender arches and spines than the presacrals. The first ones carry strong ribs anchylosed to the transverse process. These curved downward sharply, showing that the tail was heavy at the base. Chevrons are present in the anterior part of the column, but it is not known how far back they extended. Williston estimates twenty-five vertebræ in the tail.

The *humerus* has the upper and lower ends expanded and turned almost at right angles to each other; the articular surfaces are well formed. There is a prominent entepicondylar process and a good-sized entepicondylar foramen. The ectepicondylar process is extended into a distal hook. The hemispherical articular face for the radius is almost entirely on the anterior surface of the bone.

The *radius* is slightly curved, with the upper end slightly expanded and the lower end wider and thinner.

The *ulna* has a pronounced olecranon process. The shaft is curved, leaving a considerable space between it and the radius.

The *front foot* is described by Williston (**67**) as follows:

"Because of the compression of the middle part of the carpus in our specimen, it is impossible to be quite sure of the presence of both centralia. The radiale is much broader than long, articulating with the radius, the distalia of the second and third digits, and with one or possibly two centralia. The ulnare is a much longer bone, articulating proximally with the ulna, distally with the two inner distalia, and on the outer side with the intermedium. That there is a free intermedium here, as in *Labidosaurus*, is certain, but I can not be quite sure of its extent, a part of it being apparently covered over by the radius. It articulates, as in *Labidosaurus*, proximally with the ulna and distally with a centrale. Five digits are present, as was to be expected. The first is represented by its metacarpal only, either slightly removed from its articulation with the radiale, or, what is more probable, with its distale lost, or cartilaginous. In the restoration it is shown removed from the carpal bones as in the photograph of the hand also given herewith (see fig. 44). The first metacarpal is the shortest of the five, and is only moderately expanded distally. No phalanges are preserved. The second metacarpal is much longer than the first, and is much constricted in its middle. It has one short phalanx articulated with it, but little more than half the length of the metacarpal. Additional phalanges are not preserved, but, from its size, it seems very probable that two more, and not more than two, were originally present. The third metacarpal is much like the second, but is a little longer. Two phalanges are present, the first about two-thirds the length of the metacarpal; the second fragmentary. There may have been a third ungual phalanx present. The fourth metacarpal is the longest and stoutest of all, its proximal articulation more oblique than is the case with the preceding one. The first phalanx is about three-fifths the length of the metacarpal. The second phalanx, much shorter and smaller, has at its tip a small fragment. There may have been a fourth phalanx, though there is not much probability of it. The fifth metacarpal is a little shorter than the fourth, somewhat curved and more slender. It has a small and short proximal phalanx and a fragment of a distal one at its tip. In all probability there were no more. It is, it is seen, impossible to say with certainty what the phalangeal formula of *Pariotichus* was, save that quite surely it was not that of the modern lizards and *Sphenodon*, 2, 3, 4, 5, 3. In much probability it was 2, 3, 3, 4, (3), 2."

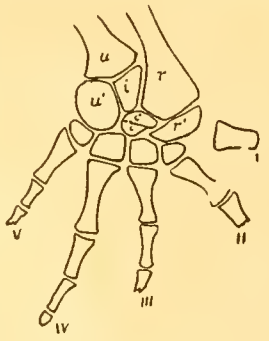


FIG. 44.—Front foot of *C. isolomus*. After Williston. × ⅔.

The *pelvis* is quite primitive. The ischia and pubes are broad and plate-like, lying horizontally in the body and meeting in a straight symphysis, but are not suturally united (*fide* Williston). There is a small pubic foramen near the anterior edge of the acetabulum. The puboischiadic suture is very indefinite, but apparently lies just posterior to the pubic foramen. The ilium stands at an angle of about fifty degrees with the pubis and ischium; the crest projected strongly to the rear.

The hind limb (from Williston's description): "The *femur* and *tibia* resemble those of *Labidosaurus*. The *fibula* is strongly curved with a considerable expansion at its lower extremity, and with a small, rounded upper end. In the *foot* a large flat *fibulare* articulates with the fibula of the right side in position, closely articulating on the inner side with another large bone, evidently the united tibiale and intermedium. Four tarsal distalia are visible. The shapes of the bones distinguished agree in general so well with those of *Labidosaurus*, as figured by me, that I have no hesitation in giving the others from the same genus, shaded in

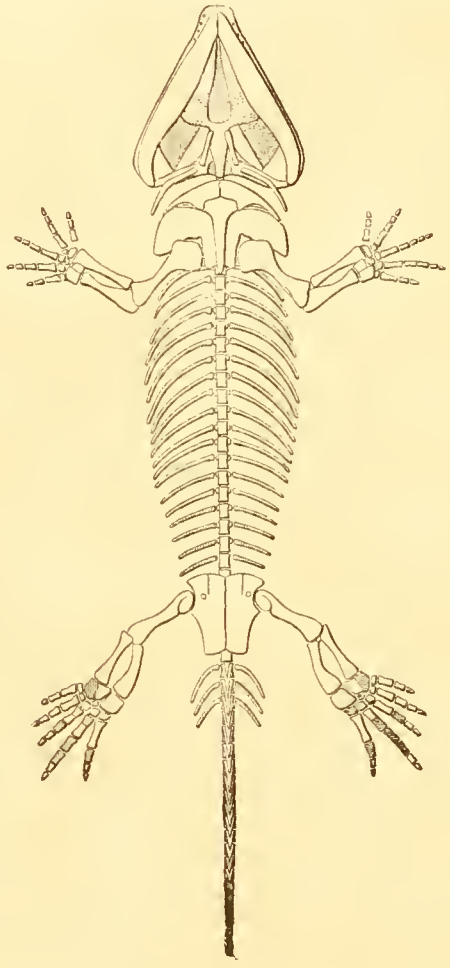


Fig. 45.—Restoration of *Captorhinus*. After Williston.

the figure (fig. 45). The tibiale, however, must have been shorter than in *Labidosaurus*. As regards the toes, all five metatarsals are visible on one or the other side, and many of the phalanges, save those of the fifth toe. In the figure given in the restoration (fig. 45) the unshaded phalanges are given precisely in the positions they occupy with regard to the tarsus, so that the length of the toes is quite certain. Those phalanges which can not be extricated from the matrix are shaded. In all probability the phalangeal formula is like that of the front feet; certainly there can not be a greater number."

The ribs: A small rib is present on the axis, and there was probably one on the atlas, but this is not known. The third cervical carries a large rib, with the proximal end broad and thin, but not divided into capitulum and tuberculum; immediately

below the proximal end the shaft is contracted and then spreads out in a wide, flat distal end. This distal expansion is noticeable on the first four vertebræ, after which the ribs are elongate and very slender. On the fourth vertebræ anterior to the sacrum there is no face for a rib, so the last articulated rib probably occurred on the twenty-first.

Abdominal ribs: Williston detected a few very slender abdominal ribs just anterior to the pelvis. They probably extended over the abdomen.

Measurements.

Type specimen of *C. aguti*, 4334 Am. Mus.	mm
Length of skull	67
Width across quadrates	47
Width of alveolar edge opposite center of orbit	25
Interorbital width	20
Length of ramus	61
Greatest depth of ramus	11
Length of humerus	34
Width of distal end of humerus	25.5

Specimen No. 4424 Am. Mus.	mm
Length of skull	70
Breadth, approximate	60
Length of humerus	35.5
Breadth proximal end	12
Breadth distal end	15.1
Length of radius	19.5
Length of pubis and ischium	35

Genus LABIDOSAURUS Cope. (Plate 12.)

Characteristic specimens: Nos. 4427 and 4876 Am. Mus. Nat. Hist., Nos. 641 and 642 University of Chicago. The mounted specimen in the Alte Akademie, Munich.

Labidosaurus is an abundant form in the upper part of the Texas Red Beds, but the specimens are commonly very imperfect and covered by a refractory matrix; recent discoveries, however, make the osteology of the genus fairly well known. The following description is taken from several specimens, notably from the work of Cope, Williston, Broili, and Case.

The *skull:* The description of the skull is largely taken from Williston's recent description of specimens Nos. 641 and 642 in the University of Chicago.

"The skull is remarkable for its attenuated facial region, and for the beak-like extension of the premaxillaries, terminating in the long, rake-like teeth. The nares, situated nearly at the extremity of the rostrum, are semioval in shape, directed outward. The face in front of the orbits is narrow, gently convex from side to side, with nearly vertical sides and a gentle longitudinal convexity in the middle. The orbits are a little longer than wide, their diameter a trifle greater than the interorbital width. Posteriorly the skull is flattened in the middle above, and greatly expanded in width, the expansion beginning near the back part of the orbits, the lateral margins curving inward at the extreme posterior part. The large pineal foramen is situated near the front part of the parietal bone, about midway between a line drawn through the hind margins of the orbits and the hind margin of the skull in the middle line. There is a pronounced emargination of the hind margin of the skull, extending the width of the parietal bones. In well-preserved specimens the markings of the surface of the skull are very distinct, consisting, for the most part, of round or oval pits forming a reticulation, but not distinctly arranged in rows. In other specimens these pits are less conspicuous, and the surface in some appears almost smooth.

"The premaxillæ are separated in several of the specimens in the museum. They unite broadly above with the nasals, by a rounded border in front of the middle of the nareal margins; and on the sides with the maxillæ, below the nares. The two bones together present a strong anterior convexity, with the alveolar border receding. Each has three elongated, pointed, slightly recurved teeth, of which the innermost is the largest, the outermost the smallest, less than half the length of the longest In

the closed mouth these teeth, or the inner ones, protrude quite a distance below the mandible, hook-like or rake-like, as shown in plate 12, fig. 4 (of this paper). This extraordinary development of these teeth and their position, in association with the narrow, compressed facial rostrum, remind one strongly of the phytosaurs and are suggestive of like habits in the living creatures; the exhumation of burrowing invertebrates from the mud or sand of the shores or shallow water. The maxillæ, free in one of our specimens, are rather slender bones, with their greatest width a little in advance of the orbits. They extend back, decreasing in width, to nearly opposite the posterior part of the orbits, uniting above in front with the elongated lachrymals, behind with the anterior prolongation of the jugals.

"I count in different specimens seventeen teeth, not very different in size, the longest a little in front of the middle of the series, and the series separated from the outermost of the premaxillary teeth by a short diastema. The nasals form the upper side of the rostrum as far as their union with the frontals, a little in advance of the orbits, curving a little downward on the sides back of the nares, whose upper borders, only, do they form. The prefrontals are subtriangular in shape and small; their

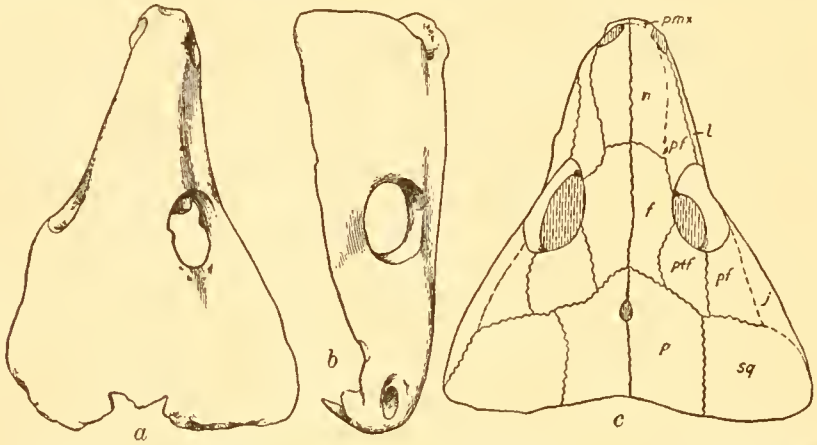


FIG. 46.—*Labidosaurus*. One of the specimens on which Cope based the genus. × ⅓. No. 4414 Am. Mus. *a*, top view, no sutures shown; *b*, side view of *a*; *c*, diagram of top of skull showing probable position of sutures. Lettering as usual.

inner sutures begin a little beyond the middle of the upper orbital margin and are parallel with each other, extending a little beyond the end of the frontal bones. The lachrymals are large bones, united broadly with the nasals, anterior to the prefrontals, and with more than half the length of the maxillæ below. They form the posterior boundary of the nares and the larger part of the anterior border of the orbits. The precise boundary between the nasals and lachrymals may be somewhat indefinite; the sutural line given is that in which four skulls seem to agree. The frontal bones have nearly parallel sides, extending posteriorly a little beyond the hind margins of the orbits, joining the parietals in a transverse serrate suture, which appears on the under side somewhat in advance of the line above. The frontals form but a small part of the upper orbital margin. The postfrontals are also small, forming the posterior upper margin of the orbit, and leaving but a small space of frontal margin between them and the prefrontals. The postorbitals are larger than the postfrontals, and also extend a little further back of the frontal suture. They form most of the hind border of the orbits, articulating with the squamosal behind and the jugal below. The jugals begin a little in front of the middle of the orbit in an acute point between the lachrymals and the maxilla. They are broader just behind the orbit, where they articulate with the postorbitals above and the squamosal

behind. Below the latter they extend as a rather narrow prolongation to or nearly to the hind angle of the skull, and to the outer extremity of the 'epiotic' bones. In the skull figured by Case and myself these posterior prolongations appear to be suturally separated from the broader part of the jugals in advance. A careful examination of other specimens, however, reveals no suture here and leads me to the belief that the supposed suture is merely a fracture in the same place on each side, due doubtless to the fact of the subangular narrowing of the jugal at this place. If there be a distinct bone here I suppose that it must be the real quadratojugal notwithstanding it has no articulation with the quadrate. All the sutures I have so far described, save perhaps that between the nasal and lachrymal, and that between the postorbital and jugal, are decisively and clearly indicated in the different specimens, some of them conspicuously so, and they, moreover, agree in the different specimens, as long and patient examinations and careful measurements testify.

"Cope's determinations of the cranial elements in *Pariotichus* and both Case's and my own in the small skull of *Labidosaurus* recognize another suture dividing the so-called squamosal into two distinct elements, though we do not agree in the position of this suture. In the *Labidosaurus* skull figured by myself there does appear to be a divisional line, indistinctly shown and agreeing on the two sides pretty well. Unfortunately, in a half-dozen other specimens showing this part of the cranial wall, some of them in the most perfect condition both above and below, I can find no trace of a divisional suture, even under the most careful examination with a lens. I am satisfied that there is none; that there is but a single bone here and not two, and this conclusion was reached before I perceived its significance in comparison with the skull of *Dimetrodon*. This large, flat and thin, or gently convex bone unites on its inner side with the parietal, on the front side with the postfrontal and postorbital, and on the lower or outer side by a very squamous and loose suture with the posterior prolongation of the jugal. This is precisely the arrangement of these bones in *Dimetrodon*, and I am satisfied that the elements are morphologically identical. The chief difference between *Labidosaurus* and *Dimetrodon* consists in the rather large vacuity of the latter piercing what otherwise would be the squamosal, jugal, and postorbital bones. For the present I accept Case's determination of the squamosal element as the prosquamosal, but I feel far less assured of its homology than I did formerly, though I doubt not that it corresponds quite with the element in the ichthyosaurs originally named prosquamosal by Owen.

"On the posterior or occipital side there are two cranial roof bones on each side, clearly and positively shown in all our specimens, one bordering the hind margin of the parietal, the other the squamosal, and called by Cope respectively the supraoccipital and the tabulare—that is, the so-called epiotic of authors. They differ from the bones of the upper surface of the skull in lacking the superficial markings or pittings, and aré suturally united with the superior bones at an angle of nearly ninety degrees. The superior or inner of these two pairs of bones, those bordering the parietals, the supraoccipitals of Cope, are the narrower of the two. Their inner ends are curved downward slightly, with an angular interval between them, into which fitted the small spine of the real supraoccipital described further on. It has long been believed that the so-called supraoccipital of the Stegocephala and of those reptiles in which a like bone is believed to occur does not correspond to the true supraoccipital of the higher reptiles and mammals. They are clearly membrane bones, and have been called the postparietals by Broom. That they are not the real supraoccipitals is very evident in this specimen, in which a large and well-defined supraoccipital is found quite dissociated from the membrane bones of the cranial

wall. These bones unite at their outer end with the upper part of the so-called epiotic; the lower, thin and somewhat concave border is free. The epiotics are broader and longer than this postparietal, with nearly parallel sides, the lower margin thinned and free and concave in outline, the upper uniting by suture with the squamosal at the angle of the skull. The inner end, which is truncate, unites above with the 'postparietal'; below it presents an oblique articular facet for union with the extremity of the paroccipital. The outer extremity is rounded below, and extends to the angle of the skull, articulating apparently with the posterior end of the jugal. On its inner surface near the roof it articulates for a large part of its extent with the hind border of the quadrate. Further observations on the homologies of this remarkable bone will be given later.

"The more complete of the two larger skulls has the palatal and basicranial regions in excellent preservation, and but little distorted. Just back of the transverse bones a recent fracture through the narrowest parts of the free pterygoids has permitted the removal of the posterior portion and its complete separation from the incrusting matrix, both above and below, enabling one for almost the first time to obtain a clear conception of the cranial bones and their relations to each other. Very remarkable is the fact that all this portion has no sutural connection with the cranial walls, the suture between the quadrate and the epiotic being the only one, indirectly connecting the vertical elements with the superior membrane bones. This will readily account for the fact so often observed, of the loss of the basioccipital and basisphenoid from the remainder of the skull, a loss which, erroneously interpreted, induced Cope to give the name Cotylosauria to the whole group. Above, in the middle, the 'postparietals' merely touch the supraoccipital, while the epipterygoids further in advance touch the parietals in a mere rounded point.

"The quadrate bone of the left side in this specimen lacks its articular head, which had been, unfortunately, broken off with a part of the articular and lost before the discovery of the specimen. The remainder of the quadrate, however, is quite in position, overlapping the pterygoids, and is complete. On the right side the quadrate, nearly complete, has been entirely separated from its articular relations. The vomers, anterior part of the pterygoids, the palatines and the transverse bones are all in their normal positions. The nares, situated far in front, probably directly below the external orifices, are concealed by the mandibles, which are closed upon the maxillæ; nor is the suture distinguishing the vomers from the posterior elements distinguishable. The narrow pterygo-palatine shelf on each side shows, on the upper side at least, a suture between the palatines and pterygoids for a portion of the distance, though I can make out no suture separating the transverse bones, though such doubtless existed. The transverse bones are stout, forming a strong declivity from the plane of the palatines, and they abut massively against the mandibles at least as far as their middle. In the middle, between the pterygoids, opposite and in front of the transverse bones, there is a large ovate interpterygoidal space, in front of which the two pterygoids approach each other closely, though not touching. Possibly in the living skull they actually met in the middle. In front of the basisphenoid the pterygoids curve inward so that they meet in the middle behind, leaving no space for a presphenoid or parasphenoid, which is certainly wanting in this specimen at least, though distinctly present in a smaller skull, and recognized by Broili in this species. The pterygoids unite firmly with the basisphenoid by this inner sphenoid process. Along the margin of the interpterygoidal opening, for nearly its whole extent, there is a row, possibly double in front, of small tubercular teeth; a patch of similar teeth is also present in front of the transverse declivity of the palatines, and yet another patch on the summit of each transverse bone.

"The posterior prolongations or quadrate processes of the pterygoids, arising just back of the transverse bones from the base of the stout sphenoid processes, are long, thin, divergent, oblique plates of bone, extending back nearly to the hind margin of the skull, articulating broadly but loosely with the plate of the quadrate as shown by the dotted lines in figure 3, plate 12 (of this paper). The inner border nearly touches the sides of the basisphenoid; the lower, thin and nearly straight border is continued to near the articular extremity of the quadrate. The basisphenoid is narrow in front, gradually widened behind, grooved in the middle, shallower in front, more deeply behind, where it is bordered on each side by a descending process which terminates in a free, thin margin underhanging a fossa that opens backward. I can not distinguish with certainty the sutural division between the basisphenoid and basioccipital, though it seems to be wholly back of the lateral processes, since in another skull, in which the basioccipital has been dislodged, the division has been made back of these processes. On either side of the basisphenoid, or the conjoined basisphenoid and basioccipital, an elongate, cylindrical or oval rod is given off, which is directed downward, outward, and backward, lying closely under the posterior end of the pterygoid plate, and reaching nearly or quite to the head of the quadrate. This process, clearly the stapes, seems to be suturally united with the basisphenoid, as indicated in figure 1, plate 12 (of this paper). The position of the bone in the specimen seems to be quite normal and undistorted, and the bone is nearly complete, though possibly the extreme end has been broken away; it seems to be perforated proximally by a small foramen. The shape, form, and relations of the basisphenoid, stapes, and pterygoids may be compared with the author's figure of the same parts in the remarkable rhachitomous amphibian recently described by myself.*

"The basioccipital bone, limited as I believe it to be in front, is small and is clearly distinguishable from the exoccipitals. Its condyle is convex, oval from side to side, somewhat pitted in its middle, and seems to be wholly composed of the basioccipital. The exoccipitals are small, apparently taking no part in the condyle. The suture limiting them from the basioccipital is clearly seen at the sides below and joining the margin of the foramen immediately at the side of the condylar surface above. The suture separating it from the paroccipital passes through the jugular foramen, thence directly upward and forward. The exoccipitals join the supraoccipital by a transverse suture a little below the summit of the foramen magnum. The foramen magnum is heart-shaped, about eight millimeters in its greater diameter. The paroccipitals or opisthotics are distinct elements, the distinguishing suture very clearly indicated, as already stated. They are stout at their base, and are turned outward and backward to end in a short cylindrical rod lying under the proximal posterior end of the quadrate and articulating at the extremity with the facet already described on the lower part of the inner end of the 'epiotic.' This articular arrangement is the normal one of the opisthotic with the epiotic in the Stegocephala. Chiefly because of this fact I am loath to identify the bone with the quadratojugal, to say nothing of the anomalous position of the bone for a quadratojugal. Anteriorly the suture separating the paroccipital from the supraoccipital passes nearly directly forward to the outer side of the posterior lateral projections of the supraoccipitals where the dividing suture turns inward. Of the suture separating the proötics I am less certain, though it seems to be quite apparent in the position I have figured it in the drawing. The supraoccipital is a large element, when seen from above having a marvelous resemblance to the arch of a dorsal vertebra. A small dorsal

* *Trematops milleri*, Journal of Geology, vol. XVII, p. 636, 1909.

spine in the middle posteriorly is intercalated in the angle between the inner ends of the postparietals, but there is no sutural attachment. Anteriorly the two sides of the supraoccipital diverge in the form of zygapophyses, with an emargination between them exposing the cerebral cavity. From the median posterior spine a ridge runs outwards to each 'zygapophysis'. In front of each lateral projection, the proötic, distinguished suturally, descends in a rounded margin to form the optic notch. In front of these optic notches there is, on either side, a thin, vertical plate, attached either to the proötic or basisphenoid below the meeting in the middle above, leaving an opening of rather small size between them. The upper end of these plates is fractured, but it is very evident that, in position, relations, and shape they agree quite well with similar bones bounding the cerebral cavity in most lizards, a small bone, usually lost in the macerated skull, whose homology is not well understood. Since their position is in front of the optic nerve it would seem to preclude the possibility of their being alisphenoids. These elements in the Mosasaurs I have identified as orbitosphenoids (see University of Kansas Geological Survey, vol. IV, pl. XXIX, f. 5; Kans. Univ. Quarterly, vol. XI, p. 249), but neither identification is quite satisfactory.

"The upper oblique surface of the pterygoid wings is concealed posteriorly by the quadrates. In front of the quadrates, and occupying nearly the whole extent of their margin and the upper half of their externo-superior surface, are the elongated and oval epipterygoids. They continue the acclivity of the pterygoid wings on the outer side a little more steeply, ending in an obtuse point a little back of the orbitosphenoid plates, which touches, but is not suturally united with, the parietals above. These epipterygoids are broader in front, where they come in contact with each other over the pterygoids. The quadrates in the larger specimens, and also in one of the smaller, are preserved nearly or quite intact, and in their natural relations. They unite with four bones only, the pterygoids by a very broad and loose union, as shown in fig. 2, plate 12 (of this paper), with the outer ends of the paroccipitals, as also shown by the dotted lines in the same figure and in fig. 3, plate 12 (of this paper), and by their posterior everted articular margin with the outer extremity of the postparietals and much more extensively with the 'epiotics' near the cranial wall. The thin, expanded proximal plate of the quadrate, as shown in fig. 3, plate 12 (of this paper), narrows into a distinct neck, chiefly by a groove which winds from the under side about the hind margin a little above the articular extremity. The notch thus formed is clearly the auditory notch, corresponding to the notch of foramen in the quadrate of the Mosasaurs and lizards; and possibly also it corresponds with the so-called quadrate foramen of the *Pelycosauria*. Doubtless the *Cotylosauria* had a small external ear situated nearly as it is in the lizards, above the angle of the mandible. The articular surface of the quadrate for the mandible is oblique to the plane of the bone, so as to look more nearly downward in the normal position of the quadrate. Its outer side projects into a rather narrow process, but does not touch, much less articulate with, the roof bones.

"The mandibles, in comparison with the skull, are stout and heavy bones, and amply attest the predaceous habits of the animals. They are slightly expanded in front, where they meet in a short symphysis, heaviest and stoutest just back of the orbits and broadest also here. They are nearly straight or gently incurved anteriorly turned inwards in a broad curve behind. The splenial bones unite in a median symphysis in front and extend back nearly to the articular, leaving a broad, elongate open cavity on the inner side from immediately back of the orbits. They also form a part of the lower margin of the mandible, visible from below as far back as the middle of the orbits, having between them and the hinder end of the dentary, an elongate and acute projection of the angular. The suture between the angular and

the articular continues the curve of the inner border of the mandible to the outer side of the extreme posterior end of the angular process. The suture between the angular and the surangular passes forward nearly midway of the mandible, and nearly parallel with the upper border in the closed jaws, to the hind end of the dentary, that is to nearly opposite the posterior end of the orbits. The thin ascending plate of the surangular reaches at the summit nearly as high as the lower margin of the orbits on the inner side of the temporal roof. Over the summit the slender posterior end of the coronoid is visible in the closed jaws, but its anterior part is concealed by the transverse bones. The articular is a short bone, turned inward, with a thin inner margin. It is apparently continued forward as a slender prolongation above the margin of the splenial or angular and forming the lower border of the mandibular cavity, to a slender, acute point nearly as far as the hind end of the mandibular tooth series. Whether or not it is separated from the articular as a distinct bone, the prearticular, or indeed of its precise relations I will not be sure. Sixteen teeth I count in the mandibular series in three different skulls. They resemble the maxillary teeth, but are somewhat smaller. The first or second is distinctly larger than the following ones.

"Perhaps nothing is more noticeable in the skull of the present reptile than the small comparative size of the brain cavity. While the skull measures over seven inches in length and five in width, the foramen magnum is of almost precisely the same size and shape as that of a small *Amblyrhynchus* lizard whose skull measures but sixty millimeters in length. Not only is the foramen of the same size, but the brain cavity also is only a trifle larger in *Labidosaurus*. Small brain capacity is of course to be expected in this old reptile, and, moreover, the size of the brain cavity as compared with that of the skull may not be a fair criterion of the relative intelligence of the two animals. Nevertheless, that their intelligence was relatively much lower than that of the existing lizards can not be doubted."

As shown in the discussion of the skull of *Captorhinus*, page 96, the bones described by Williston as epiotics can not be such, for these bones are present as small, triangular nodules between the parietals, squamosals, and the supraoccipital plates (Williston's postparietals). The outer of the two plates on the posterior surface of the skull are, as Williston suggests, probably homologous with the bones of similar position in *Dimetrodon* and are most probably the quadratojugals; reasons have been given for not accepting Williston's objections to this homology as decisive.

The *vertebral column:* The specimen described by Case (**11**) had but eighteen presacral vertebræ; Broili (**7**) described twenty-two in his specimen, and Williston is of the opinion that at least two must be missing from the specimen described by Case. A complete specimen, No. 4876 in the American Museum, has twenty-five. It is altogether probable that more than one species is represented in the numerous specimens, but it is impossible to determine this point. It is only certain that the genus *Labidosaurus* had a maximum number of twenty-five presacral vertebræ.

The *atlas* and *axis* are present in No. 4876 Am. Mus., but are obscured in part by the skull. There is a good-sized atlas centrum, but the neural arches are lost. Broili describes a keel in the lower surface of the centrum in his specimen. Evidence of a preatlantal intercentrum is also present. The spine of the axis is broken off and lost, but the neural arch shows it to have been quite heavy. The transverse processes are set high up on the sides of the neural arch and the face for the rib is short; there seems to be a small diapophysis present on the centrum, indicating that the rib was perhaps double-headed. The transverse process of the third vertebra has an elongate face for the wide proximal end of the single-headed rib.

Posterior to the axis the presacral vertebræ are very similar in form. They are of the same general type found in the *Diadectidæ* and *Pareiasauridæ*. The centrum is notochordal with wide funnels at the anterior and posterior ends; the lower line is shortened for the accommodation of intercentra. The neural arches are low and wide and swollen, so that the upper surface looks almost hemispherical. The spines are low and short, bifurcate in the anterior vertebræ, but more posteriorly, terminating bluntly as if they might have been attached to some dermal plate above. The zygapophyses are large and perfectly horizontal. There is no zygosphene or zygantrum. The neural arch is coossified with the centrum. The transverse processes have elongate terminal faces for the single-head ribs; these are shorter than the rib heads, which were either attached to the intercentra directly or by cartilage. All the vertebræ were bound closely together by the wide overlapping of the zygapophyses and by strong ligaments lodged in a pit at the base of each neural spine behind. The transverse processes diminish in size in the posterior part of the series and the last four or five presacrals did not carry ribs.

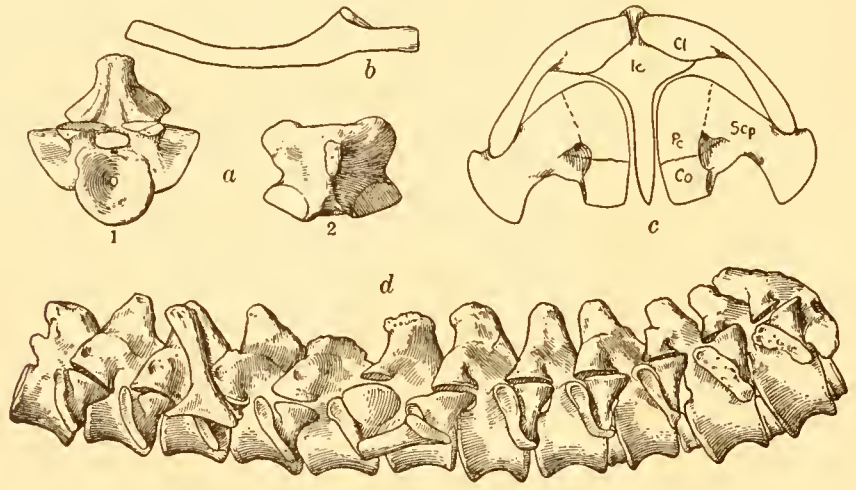


FIG. 47.—*Labidosaurus*. ×⅔.

a, dorsal vertebræ. 1, front view; 2, top view of same vertebra. No. 4875 Am. Mus.
b, rib of the anterior dorsal series. No. 4550 Am. Mus.
c, shoulder girdle. *Cl*, clavicle; *Ic*, interclavicle; *Scp*, scapula; *Co*, coracoid; *Pc*, procoracoid. After Williston.
d, cervical and dorsal vertebræ.

There are two sacral vertebræ which have more elevated and slender neural arches than the presacrals; they are not united into a sacrum.

The *caudal vertebræ* have more slender neural arches, resembling in this regard the sacrals rather than the presacrals. They diminish rapidly in size and are about seventeen in number (Broili).

The *ribs* (fig. 47, *b*) have expanded proximal and distal ends; the capitulum and tuberculum are not separate, with the possible exception of the axial rib, but are clearly indicated in the anterior dorsals. The rib of the third vertebra is bent at almost a right angle, but those of the posterior vertebræ are more nearly straight. The distal end is wide and spatulate.

The anterior *sacral rib* is very large, with the distal end as wide as the centrum is long. The rib of the second sacral is much more slender than the first and its distal end underlies that of the first rib; both extend almost directly outward from the vertebræ.

The *shoulder girdle* (fig. 47, *c*): The *interclavicle* is rhomboidal with a strong posterior prolongation; the *clavicles* are expanded at the anterior end and overlap the interclavicle; the outer surface of the clavicles and interclavicle is not sculptured, but the edge of the latter is marked by rugose striations where it is overlapped by the clavicle. The distal end of the clavicle is striate. There is no *cleithrum*.

The *scapula* is rather short and the distal is turned dorsally, almost at a right angle to the coracoidal portion. There is a good-sized *coracoid* which takes large part in the cotylus for the humerus and is separated from the scapula by a distinct suture. The suture between the procoracoid and scapula is less certain, but seems to have been present. There is a distinct foramen between the procoracoid and the

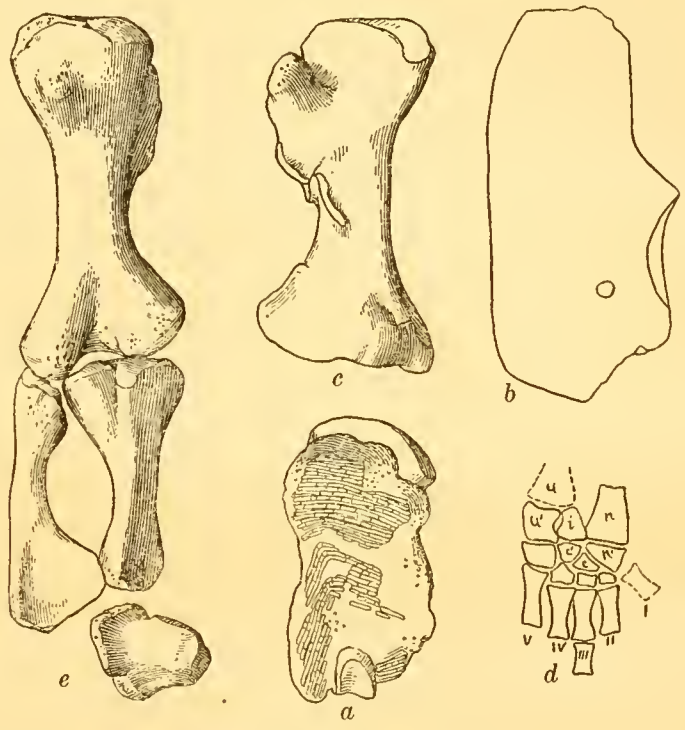


FIG. 48.—*Labidosaurus*. ×⅔.

a, abdominal ribs; *b*, right side of ischium and pubis. No. 4876 Am. Mus. *c*, femur. *d*, outline of the carpus; *e*, posterior limb, showing femur, tibia, fibula, and astragalus. No. 4883 Am. Mus.

scapula. In some of the specimens the sutures between the scapula, coracoid, and procoracoid have completely disappeared.

Abdominal ribs were present as numerous small rod-like ossicles.

The *pelvis* is formed by the closely united ilium, ischium, and pubis, from between which the sutures have entirely disappeared in many specimens. The *pubis* is, as in *Captorhinus*, very short and the pubic foramen is near the anterior end; the *ischium* is elongate, extending a considerable distance posterior to the acetabulum. Both bones lay nearly horizontal and with those of the opposite side formed a typically flat and primitive pelvis. The ilium rises almost at right angles to the other two bones; the upper end is somewhat expanded and projects to the rear (plate 8, figs. 4, 5, 6).

The *anterior limb and foot:* The *humerus* is relatively short, with wide proximal and distal ends turned almost at right angles to each other. There is a total lack of the strong processes and general heaviness found in the humerus of the

Diadectidæ. The condyles are not well developed; the articular face on the proximal end is not distinct.

The shaft is slender and has a triangular section. There is a distinct entepicondylar process, an entepicondylar foramen, and a well-marked hemispherical articular process for the head of the radius, almost entirely on the anterior surface of the bone. In the descriptions of *Labidosaurus* by Case and Williston the humerus was described as not having an entepicondylar foramen, but this was an error due to the condition of the specimen.

Only the proximal ends of the *ulna* and *radius* are known. The first shows a definite, but not well-developed olecranon process. "The *front foot* (fig. 48, *d*) of the left side has been preserved; the distal ends of the radius and ulna are nearly in their normal positions; the bones of the carpus are all present, with the possible exception of the first carpal of the distal row. There are well-formed scaphoid and cuneiform bones, and between these an elongate element that was at first regarded as the missing metacarpal I, but it seems more probable that it is the lunare (intermedium); the upper end is incomplete, and the lower is much the same in appearance as the end of the metacarpals; on the other hand, it occupies just the position of the

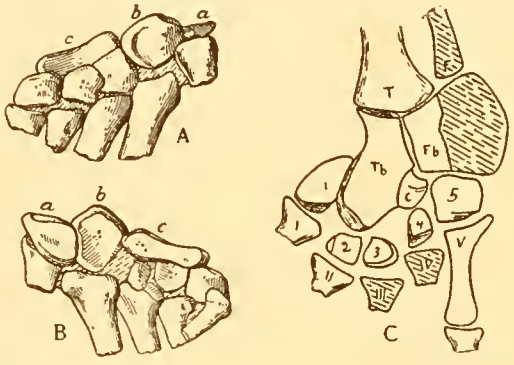


Fig. 49.—*Labidosaurus*. No. 4883 Am. Mus. × ⅔.
A. Distal portion of the tarsus. Dorsal surface.
B. Ventral surface of same.
C. Restoration of tarsus. After Williston.

intermedium, in a carpus that has been preserved in a very perfect manner, and it fits the position it occupies very accurately. According to this interpretation there are two centrale. There are four bones in the distal row of the carpus; the first is very much larger than the others, and appears to represent the first and second combined; the outer edge is a rounded process, with no face for articulation with another carpal. It is possible that the first metacarpal was attached to this bone with the second, but no traces of such a metacarpal remain. The metacarpals are short and stout, with well-developed articular condyles. The phalanges are not in contact with metacarpals, but a series which corresponds very closely to the fourth in size shows that they were also very short and strong. It is impossible to say whether there were more than three phalanges or not. Fig. 48*d* (of this paper) shows the arrangement of the bones very little altered from their position in the matrix." (Case, 11.)

The *posterior limb and foot* (plate 8, figs. 7, 8*a*, 8*b*, and fig. 48): The *femur* is short, but well formed. There is a deep concavity on the posterior surface and a prominent trochanter with a short rugose ridge at its lower end. The distal articular surface is not divided by a median groove, as in the *Pelycosauria*, but presents distinct faces for the tibia and fibula. The *tibia* is short, with proximal and distal ends equally expanded. There is the usual deep groove on the anterior

face of the proximal end which is continued as a deep groove on to the proximal articular surface. The shaft is curved slightly outwardly and much more anteroposteriorly. The distal end is divided between short horizontal face and a larger one inclined upward and inward; both of these articulate with the astragalus.

The *fibula* is slightly expanded at the proximal end with a concave facet on the posterior surface, into which fits the head of the tibia. The shaft is slender, the distal end expanded and thin with three facets.

The *tarsus* has eight bones. The *astragalus* resembles, to some extent, the same bone in the *Pelycosauria;* there are prominent articular faces on the distal end

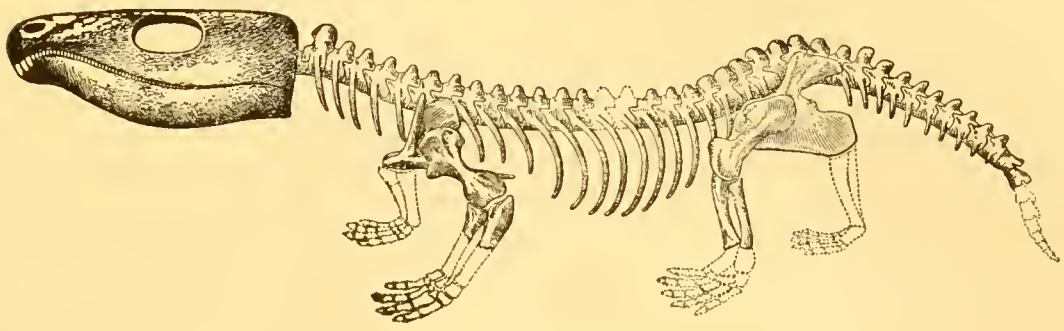


FIG. 50.—Reconstruction of *Labidosaurus*. After Broili. About $\frac{1}{5}$ natural size.

and the outer side of the distal portion. On the inner side, the astragalus is closely united to, or fused with, a small centrale. Above, the astragalus and calcaneum are in close contact, but there is a distinct foramen between them. The calcaneum is flat and thin and roughly round in outline. There are five distal elements.

The number of phalanges is uncertain, but it seems probable that the primitive number 2, 3, 4, 5, 3-4 was present. The phalanges were fairly long and heavy, indicating that the animal had a large, well-formed foot.

Measurements.

	mm
No. 641 University of Chicago:	
Greatest length of interclavicle	77
Greatest breadth of the head of the interclavicle,	23.5
Anteroposterior length of scapula-coracoid	52.5
Breadth of same at humeral cotylus	36
Length of the head on median line from posterior edge to a point opposite middle of nares	120.5
Interorbital width	26
Breadth of skull at posterior end	127
Breadth across orbits	80
Breadth across nares (approximate)	30
Length of lower jaw	150
Greatest length of humerus	66
Breadth of lower end of humerus	30
Breadth of lower end of femur	26.5
Specimen described by Broili:	
Total length of skull in the middle line	185
Breadth of skull near posterior end	165
Breadth of skull at posterior end of orbits,	13
Breadth of skull at anterior end of orbits,	7
Breadth of skull at end of snout.	2
Length of anterior nares	18
Breadth of anterior nares	1
Specimen described by Broili—Continued.	mm
Distance between nares	21
Distance posterior border of nares to anterior border of orbits	51
Length of the orbits	4
Breadth of the orbits	3
Distance between the orbits	27
Distance of orbits from edge of skull	7
Height of the skull above foramen magnum	8
No. 4883 American Museum:	
Length of femur	70
Width lower end of femur	35
Length of tibia	49
Length of fibula	56
No. 4876 American Museum:	
Length of tibia	43.5
Length of fibula	50.5
Length of tarsus and foot as laid out	83
No. 4394 American Museum:	
Length of interclavicle	107
Breadth of anterior end of interclavicle	55
Length of scapula	106.5
Greatest diameter of cotylus	50

Labidosaurus was a low, squat creature with relative large feet and a powerful tail. It probably rested normally with the belly on the ground and only occasionally assumed the more erect position shown in the accompanying reconstruction (fig. 50) copied from Broili. Williston believes that the powerful hooked incisor teeth may have been used to drag small invertebrates from crannies in the rock or to detach closely clinging limpet-like forms.

Family SEYMOURIDAE.

Genus CONODECTES Cope.

Conodectes favosus Cope.

Characteristic specimen: The type, No. 4342 Am. Mus. Nat. Hist. Cope Coll.

Conodectes was described by Cope with *Otocœlus*, and the two were placed in the family *Otocœlidæ*, but as *Octocœlus* is an amphibian the name of genus and family are transferred to that class. *Conodectes* is represented by a single poorly preserved skull, but as it is reptilian and resembles *Seymouria* Broili very closely in some respects it is united with that genus in the family *Seymouridæ*.

The skull is in such wretched condition that the sutures can not be made and it has been largely restored in plaster by Cope.

The otic region is peculiar in the elongation of the epiotic notch at the anterior end. This is continued inward and downward until it terminates in a deep pit. On the lower surface the broad plates of the prevomers, palatines, and pterygoids can be made out. The latter approach each other in the median line, and this is the chief reason why the animal is regarded as a reptile. There is no trace of teeth on these bones, but there may have been such in life. The maxillary teeth were uniform in size, but are too poorly preserved to show more than their form. Broken teeth do not show any radiation of the dentine from a pulp cavity. The parasphenoid was apparently of small size.

Genus SEYMOURIA Broili.

Seymouria baylorensis Broili. (Plate 13.)

Characteristic specimen: The type in the Museum of the Alte Akademie, Munich.

The *Cotylosauria* can no longer be regarded as the primitive type of the reptile, as the bones of the temporal region are widely different from those of the *Stegocephalia*. Broili (**5, 6**) has amply demonstrated the strikingly amphibian resemblances of *Seymouria*, but his original belief that there were three bones in the temporal region is unfounded, and *Seymouria* takes its place close to *Captorhinus* and *Labidosaurus*. The presence of an intertemporal bone places it in a distinct family. The suggestions, founded on Broili's belief in the presence of three bones in the temporal region, that *Seymouria* would perhaps turn out to be the connecting form between amphibians and reptiles, must be abandoned. Such a form when found will probably be among the numerous small forms which were so abundant at the close of the Carboniferous.

The holospondylus vertebræ and the small parasphenoid are the characters which proclaim its reptilian nature.

The structure of the palate, shoulder-girdle, and ribs in *Seymouria* is similar to that of the *Labidosaurus;* the skull is wonderfully Stegocephalian, but the structure of the shoulder-girdle in *Labidosaurus* is so much like that of such Stegocephalians as *Trimerorhachis* that *Seymouria* approaches very closely to both classes.

Family PANTYLIDAE.

Genus PANTYLUS Cope.

Pantylus cordatus Cope.

Characteristic specimen: The type, No. 4330 and No. 4331 Am. Mus. Nat. Hist. Cope Coll.

The type specimen consists of a skull with the upper portion well preserved, lacking only the bones of the temporal region, but with the course of the sutures preserved on the cast of the lower surface. The lower jaw of the right side is in place. The left jaw is broken away at the middle of the maxillary. The bones of the back of the skull and the palate are largely destroyed.

Originally referred by Cope to the Stegocephalia (**24**), *Pantylus* was recognized by him as a reptile in 1882 (**26**). In 1892 (**35**) he compared *Pantylus* with *Chilonyx*, noting that it differed in the fact that the suspensorium was directed straight downward instead of forward. In the series of figures there published for the first time and several times repeated (**36, 42, 44**) Cope figured this animal correctly as having the full complement of bones in the temporal region, i. e.,

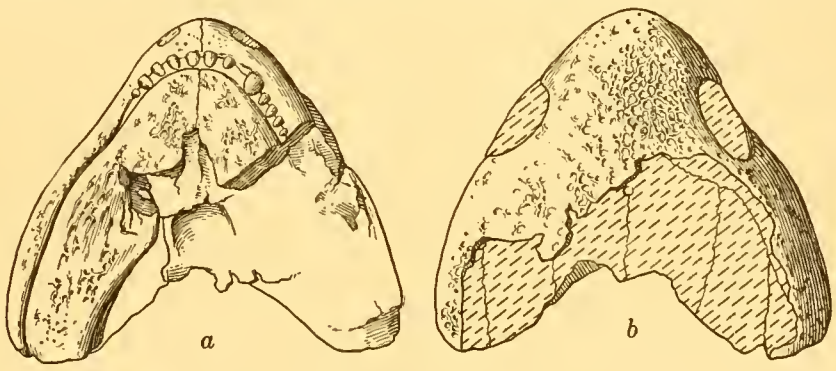


FIG. 51.—Skull of *Pantylus cordatus*. × ⅔. No. 4330 Am. Mus.
a, lower view; *b*, upper view.

squamosal, prosquamosal, jugal, and quadratojugal. The posterior portion of the prosquamosal is bent nearly at right angles and forms a portion of the vertical posterior surface of the skull. There is no trace of the tabulare; it was either absent or was reduced to small size, as in *Captorhinus*, and has been destroyed with the median portion of the supraoccipital in the injury to the back of the skull. The quadrate was originally completely covered, but the breaking away of the bones of the temporal region shows that its upper part was a thin plate reaching to the top of the skull and in contact with the quadratojugal, prosquamosal, and squamosal. The inner face was overlapped by the vertical posterior end of the pterygoid. On the lower surface can be seen the sphenoid processes of the pterygoids. Anterior to these the inner edges of pterygoids are concave, leaving a large interpterygoid space. The edges of this portion of the pterygoid are lined with minute teeth. This peculiar vertical termination of the posterior part of the skull extends to the posterior end of the lower jaw.

On the left side the posterior portion of the maxillary is broken away, showing a closely set group of strong crushing teeth on the palate, and in specimen 4331 the posterior portion of the lower jaw shows a corresponding and opposed set. In this regard *Pantylus* resembles *Naosaurus* (*Edaphosaurus*); it is, however, but a development of the condition found in *Captorhinus*.

The maxillary and premaxillary teeth are much heavier and more blunt than in *Captorhinus* and exhibit nothing of the diversity shown in *Edaphosaurus*. The posterior portion of the maxillary is covered, and it is impossible to say whether there was more than one row of teeth or not, but it is possible that there was but one, as the function of these in *Captorhinus* was probably taken by the patch of blunt teeth on the palatines and pterygoids, as in *Edaphosaurus*.

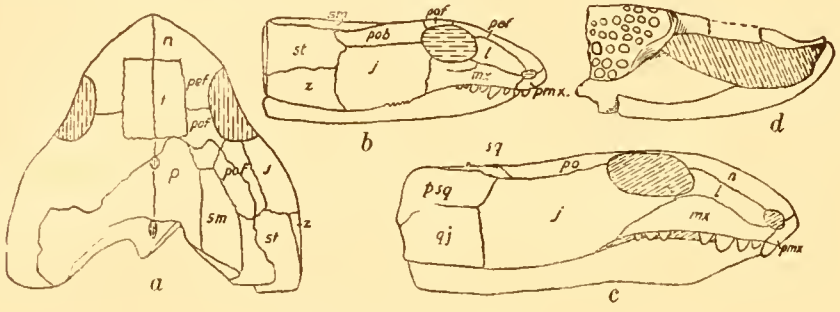


FIG. 52.—*Pantylus cordatus*.

a, Restoration of upper surface. After Cope. Lettering as in previous figures. × ½.
b, Restoration of side of skull. After Cope. Lettering as in previous figures. × ½.
c, Restoration of side of skull, according to the author's interpretation. × ⅔. No. 4330 Am. Mus.
d, Upper view of fragment of left lower jaw. × ⅔. No. 4331 Am. Mus.

The lower jaws, as shown in specimen No. 4331, were nearly flat on the lower surface and the inner surface was nearly vertical, so that the two surfaces met in a right angle. The patch of teeth mentioned above is arranged in seven irregular rows; the anterior edge of the patch is broken away, so its anterior extent can not be made out; the anterior part of the jaw, specimen 4330, has but a single row of teeth; a fortunate break shows that the first was small and the second abruptly larger.

A small fragment of a lower jaw, No. 4445, was labeled by Cope *Pantylus tristychus*. It was never described and is in all probability from an old individual of *Captorhinus*.

CONCLUSION.

The order *Cotylosauria*, as defined in this paper, includes all the primitive reptiles with a complete roof over the temporal region of the skull, single-headed ribs, and the neural arches of the vertebræ broad and low, with swollen sides and short spines. It has become increasingly apparent during these studies that the order *Cotylosauria*, as defined by Cope, was very far from occupying the primitive position assigned to it by him. The forms on which he based the order, now confined to the suborder *Diadectosauria*, can only be considered as a very specialized branch of the primitive stem.

The order originated as early as middle Pennsylvanian time (*Eosauravus* Case and *Sauravus* Thevinin) and spread over the world. By upper Pennsylvanian time widely different suborders were established in North America, in Pennsylvania (18), and perhaps Texas (17); in the Permian other suborders were established in Germany, South Africa, and Northern Russia and a little later, in the Trias, they had spread to Scotland and over Central Europe. The wide distribution of the order in middle Permian time indicates very clearly its much earlier origin, unless we resort to the improbable assumption of a diphyletic origin.

It is impossible to point with any degree of confidence to the place of origin of the order. *Eosauravus*, from the beds of Alleghany age in Linton, Ohio, is the oldest-known reptile, but *Sauravus* of France is nearly as old. The *Cotylosauria* of North America were of Pennsylvania or lower Permian age. A consideration of the following table makes it apparent that most of those of the Old World were a little younger.

Name.	Locality.	Geological Horizon.
Pareiasaurus	South Africa	Pareiasaurus Beds, Beaufort, Middle Permian.
Anthodon	South Africa	Pareiasaurus Beds, Beaufort, Middle Permian.
Propappus	South Africa	Endothiodon Beds, Beaufort, Upper Permian.
Procolophon	South Africa	Procolophon Beds, Beaufort, Middle Trias.
Thelegnathus	South Africa	Cynognathus Beds, Beaufort, Middle Trias.
Saurosternon	South Africa	Endothiodon Beds, Beaufort, Upper Permian.
Pareiasaurus	Russia	Dwyna River, Upper Permian.
Elginia	Scotland	Gordonia Beds, Bunter, Lower Trias.
Telerpeton	Scotland	Stagonolepis Beds, Keuper, Upper Trias.
Sclerosaurus	Germany	Ruhen near Basel, Upper Bunter, Lower Trias.
Phanerosaurus	Germany, near Zwickau	Rothliegende, Middle Permian.
Stephanospondylus	Germany	Rothliegende, Middle Permian.
Sauravus	France	Upper Stephanien.

This does not establish the origin of the group in North America, however, as *Sauravus* indicates their early presence in Europe. One thing is certain, the *Cotylosauria* of North America were isolated from the Old World during the Permian and developed types peculiar to the continent; whether they gained access to Europe in the Triassic is uncertain. The *Pelycosauria*, which developed with the *Cotylosauria*, migrated as far as Bohemia in the Permian and existed in Europe after they had died in America. This has not been shown conclusively for the *Cotylosauria*, though evidence of certain foreign forms brought out in this paper point to the same thing. It is possible that the group, indigenous to America, became extinct there,

still it would occasion no surprise to find American Cotylosaurs in the European deposits of Permian age or younger; for if such specialized types as *Naosaurus* could migrate from Texas to Bohemia, even such slow-moving forms as *Diadectes* and *Captorhinus* could do the same.

As in the case of the *Pelycosauria*, it is probable that the *Cotylosauria* endured longer in the Old World than the new. They occur through the Permian and into the Triassic. Specialization did not progress so far in America as in Europe, for we have in *Chilonyx* only the beginning of the development of prominent tubercles and spines in the skull, such as marks the extreme types, *Elginia* from the Trias of Scotland and *Pareiasaurus* from the Upper Permian of North Russia. Moreover, there is no certainty of any defensive dorsal armor in the American *Cotylosauria*, while it was well developed in the European and African forms. The peculiar development and posterior inclination of the incisor teeth in *Labidosaurus* and *Captorhinus* is also not found outside of North America.

Broom (10*a*) has recently expressed the idea that there is a distinct genetic relationship between the American and South African Permian reptiles. He considers that the groups had a common origin somewhere in the northern part of South America, and from there spread to North America and were there isolated, and later to South Africa across the Antarctic Continent. He says:

"Taking all the facts into consideration, it seems to me probable that in Upper Carboniferous times there appeared in the northern part of South America a primitive land vertebrate fauna comprising, among other types, temnospondylous amphibians, primitive Cotylosaurians, and primitive ancestral Pelycosaurs. Before the conclusion of the Carboniferous period this South American fauna invaded North America and almost immediately afterwards the northern group became isolated. The isolation continued during at least the whole of the Lower Permian time, and these isolated types became greatly specialized in their struggle with some adverse conditions. What the conditions were, we do not know; and no satisfactory explanation has, I think, been given of the development of the enormous spines of the vertebræ in the Pelycosaurs. Nor do we know what caused the extinction of the whole fauna about Middle Permian times, but most likely some change in climatic conditions.

"In South Africa the first Karroo reptile to appear is *Mesosaurus*, which is found in beds a little above the Dwyka tillite. It is certainly generically similar to the *Mesosaurus* of Brazil and closely allied specifically. This occurrence of *Mesosaurus* on both sides of the Atlantic, as well as a series of plants which are specifically identical in Brazil and South Africa, renders it practically certain that there was a land connection between South America and South Africa in Lower Permian times, and that animals might have migrated from what is now the one continent to the other. There is, however, no evidence that any reptiles other than *Mesosaurus* arrived in South Africa till some considerable time after the origin of the Permian. Perhaps the reason for this may be that about the beginning of the Permian period South Africa and probably much of South America, Australia, and India was, from some cause or other, largely covered by glaciers, and possibly for long afterwards the climate was too severe to allow the more northern or equatorial types to invade the south. In beds which are called Ecca we get the earliest immigrants—a large carnivorous reptile called *Archæosuchus*, which may have been a Dinocephalian, and evidence from a tooth of a large undoubted Dinocephalian which was a herbivore. It is, however, not till Middle Permian times that the fauna becomes rich. Then

there appear Pareiasaurians, a considerable variety of Dinocephalians, many Therocephalians, a few Anomodonts, the only known Dromasaurians, and a temnospondylous amphibian. Where this great collection of forms came from is of course unknown. They can hardly have originated in South Africa, because though the lower Permian beds are lithologically exactly similar to those of later Karroo times, they are almost entirely unfossiliferous.

"It seems to me, however, probable from the general resemblance of the African fauna to the North American Permian, that both have come from the common source, which I believe must have lived in the northern part of South America. After the invasion of North America in Upper Carboniferous times, all connections between North and South America ceased for a very long period. The near relatives of the ancestors of the North American Permian forms left in South America evolved on quite other lines. For long they were probably confined to the Brazilian region owing to the cold prevailing in the South, but ultimately they spread down and across the South Atlantic into Africa, where they, for the most part, arrived during Middle Permian times.

"If this conclusion be correct we may regard the American and South African Permian faunas as derived from a common origin, but having evolved in quite different directions. The American types undergo many curious specializations; the African, or more preferably the South Atlantic type, is chiefly remarkable for the great development of the limbs. The Pareiasaurians, the Dinocephalians, the Therocephalians and the Anomodonts have all developed powerful limbs, and not improbably all independently of each other."

These conclusions of Broom are contrary to the opinion which has prevailed among American workers on the Permian reptiles. They have held that the American Cotylosauria and Pelycosauria are distinct and indigenous. Broom's summary of evidence only cites as common characters the most primitive features, which all date from the time when the reptiles separated from the amphibians. Such a relationship of the two groups must be admitted, but it can only be very remote. The strikingly similar general appearance of the groups as a whole, which appeals to every observer at first glance, is very probably due to the parallel development of very plastic groups in a similar environment. Such characters as follow the lines of development in each group seem to indicate wide differences.

The *Cotylosauria* is still regarded as the most primitive order of reptiles, though far from occupying the direct relationship to the *Stegocephalia* formerly assumed. It is a very large and comprehensive order, of world-wide distribution, containing several highly specialized suborders. The table of comparable characters (pages 63–66) shows how widely separated were some of its members. Though some forms, as *Seymouria* and perhaps *Stephanospondylus*, approach very close to the *Stegocephalia* in the character of skull, they are widely separated from them in other characters. It now appears we must turn to some of the small and less well-known *Cotylosauria* to find the probable connecting link between the reptiles and amphibians. It may well be that none of the forms now known will turn out to be the connecting form, but the most hopeful path leads in the direction of some of the smaller forms, such as *Gymnarthus*, now placed provisionally among the amphibians.

The primitive form seems to have been a small creature with a low, flat skull containing all the bones of the Stegocephalian skull and without an epiotic notch. The quadrate was covered and the parasphenoid bone was reduced to a rostrum

of the basisphenoid, but was still of good size. The vertebræ were notochordal, the neural arches were low and broad, with the zygapophysial faces horizontal and with short stout spines. This character of the neural arches of the *Cotylosauria* seems to be one of the most persistent features and to be peculiar to the primitive reptiles. (It occurs in the Proganosaurian *Mesosaurus*, which is very probably an aquatic adaptation of the Cotylosaurian type and retains many of the primitive characters.) The ribs were single-headed and attached to the transverse processes. (It is asserted by Williston and Moody that the ribs of *Eosauravus* are intercentral in position. This is the most puzzling thing about the specimen; if it were not for this, it would form a very satisfactory connecting link between the reptiles and amphibians as far as the posterior portion of the skeleton goes.) There were about twenty-three or twenty-four presacral vertebræ, two sacrals, and twenty or more caudals. Abdominal ribs were present. The shoulder girdle of the primitive form had the coracoid and procoracoid united with the scapula; cleithrum present. The ilium and ischium were flat and plate-like and the bones of the opposite sides met in a straight symphysis, but were not united. The articular surfaces of the limb bones were well formed. The two ends of the humerus were turned almost at a right angle to each other and there was an entepicondylar foramen. The carpus had radiale, intermedium, and ulnare, probably two centrale, and five bones in the distal row. The phalangeal formula was almost certainly 2, 3, 4, 5, 3. The tarsus had tibale, fibulare, five bones in the distal row, and a pisiform.

The departure from this primitive type was:

1. The change in position of the bones over the temporal region. In some the supraoccipital plates became vertical, the quadratojugal took a position on the posterior surface of the quadrate, and the temporal region was covered by only two bones. In others the temporal region retained the three bones of the primitive cover.
2. The development of an epiotic notch and the final uncovering of the quadrate in some forms.
3. The separation of coracoid, procoracoid, and scapula.
4. The ischium and pubis became more nearly vertical and met at the symphysis in an angle.
5. The tarsal bones of the proximal row became united in a single large element.
6. The phalangeal formula became reduced in some.

There is no single one of the *Cotylosauria* that can be considered as an ancestral form of the other reptiles. It is impossible to derive the Diapsidan and Synapsidan types from the known Cotylosaurs; perhaps some primitive form may have given rise to the single and double arched types by perforation of the roof, but the result of these studies has been to render this less probable and certainly to exclude any form yet discovered from such an ancestral position. The theory which places *Sphenodon* as the representative of the primitive form derived directly from the *Cotylosauria* is inadequate to explain the facts.

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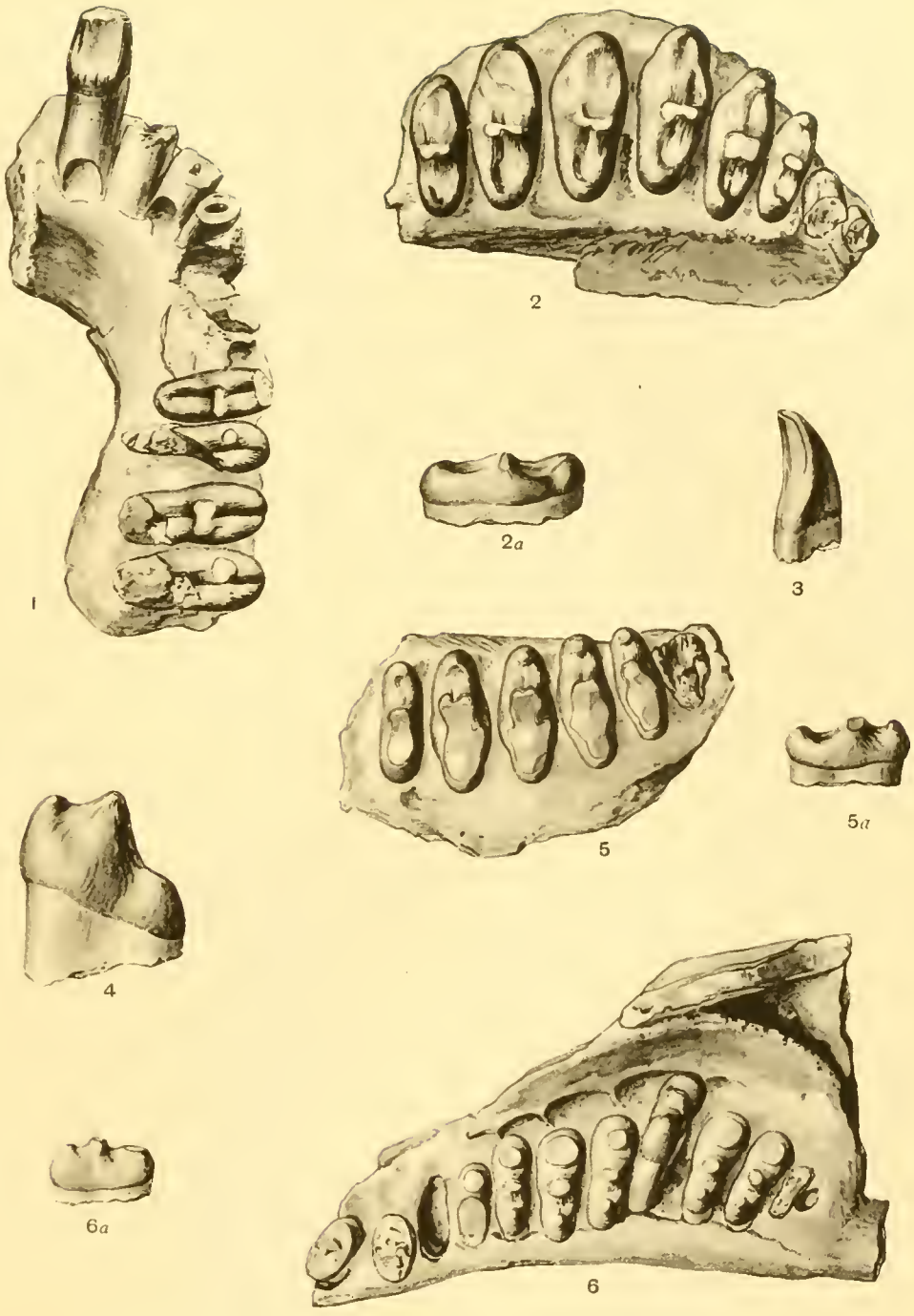

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6. Right maxillary of *D. phaseotinus*. × 1. No. 4349 Am. Mus. 6*a*, Lateral view of tooth from same specimen.

1

2

Skull of *D. phascolinus*. × ¾. No. 4839 Am. Mus.
1, lateral view; 2, upper view.

1. Posterior view of skull of *D. phaseolinus*. × ¾. No. 4839 Am. Mus.
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1. Upper view of skull of *Diadectes* sp. × 3/5. No. 4352 Am. Mus.
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6. Tibia of same specimen.
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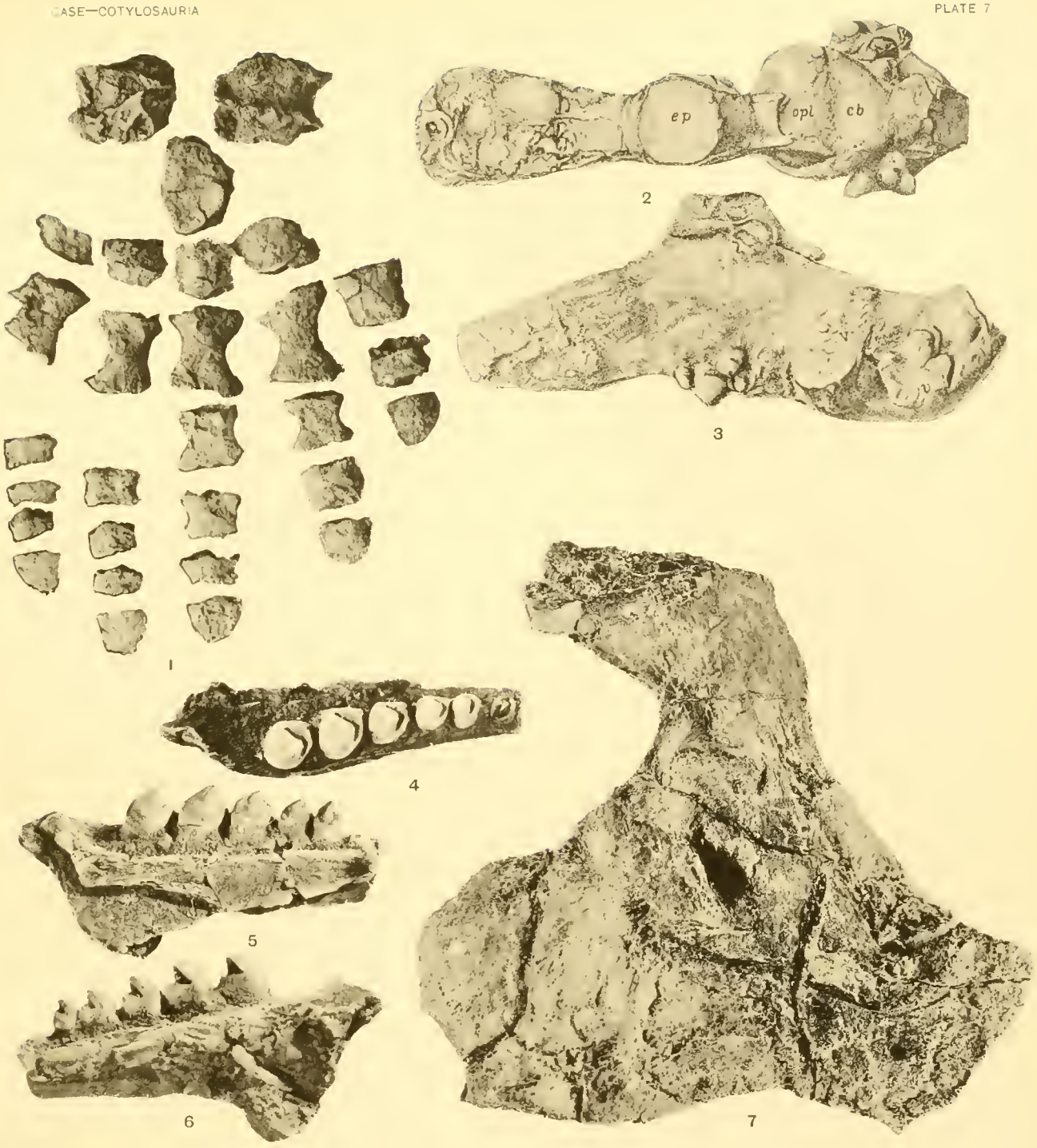
8. Left humerus, posterior view, of same specimen.
9. Right humerus of same specimen.



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6. Same, outer view.
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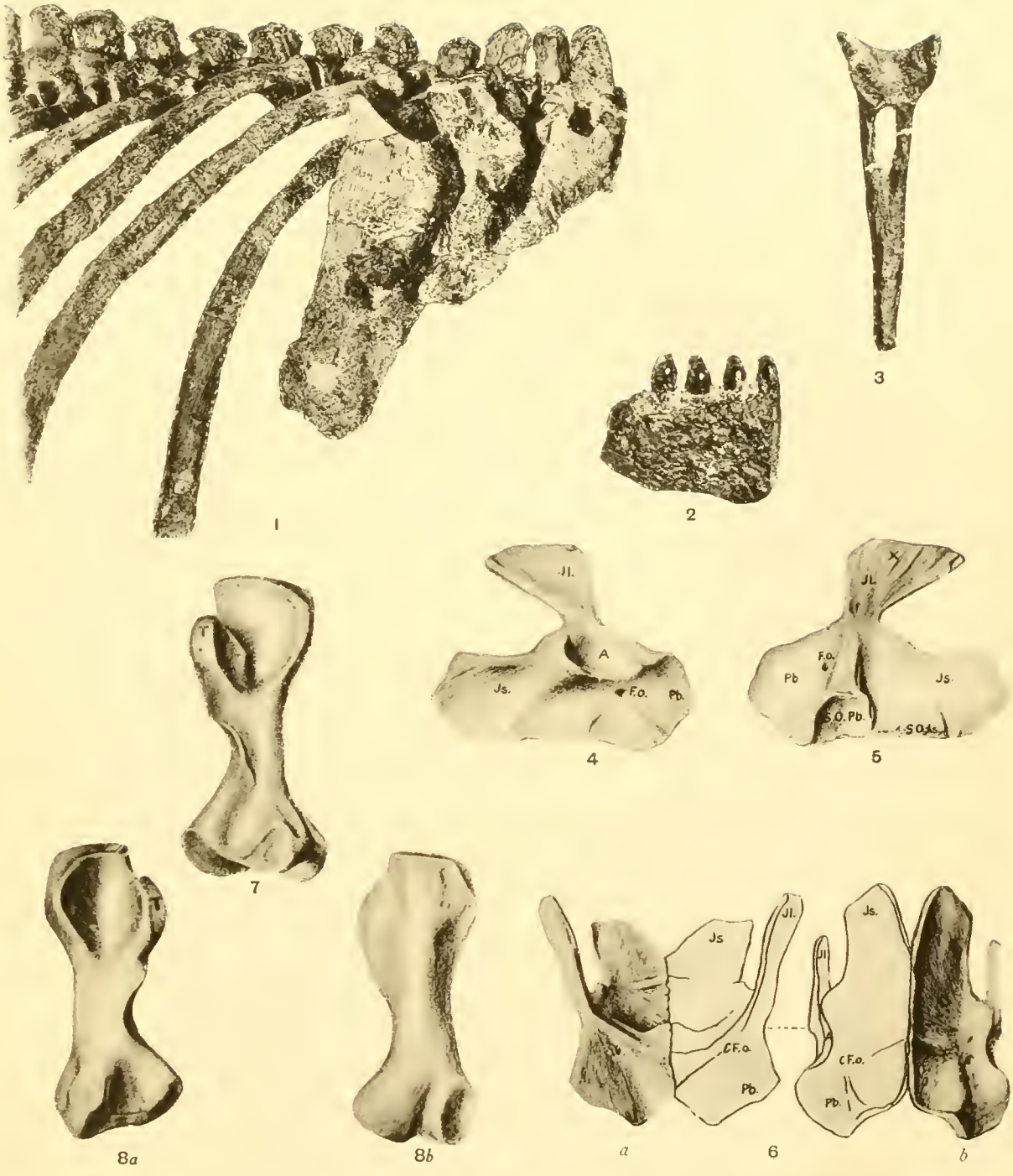

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7. Right femur, *Labidosaurus*, lower view. × ⅔. After Broili.

8*a*. Left femur from below. 8*b*, Same, from above. After Broili.

Anterior view of pelvis of a diadectid reptile. × 1. No. 4373 Am. Mus.

1

2

1. Lateral view of skull of *B. tenuitectus*. × ⅔. No. 4375 Am. Mus.
2. Top view of skull of *Chilonyx*. × ⅔. No. 4357 Am. Mus.

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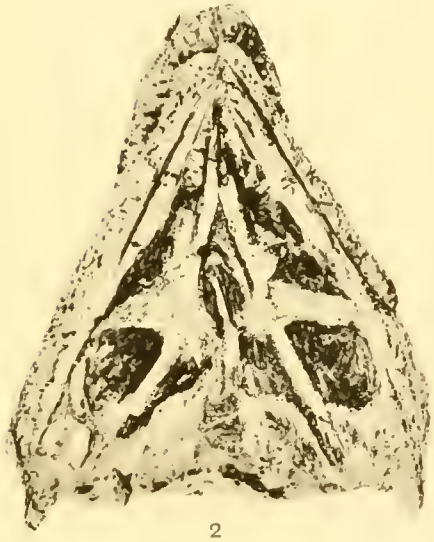

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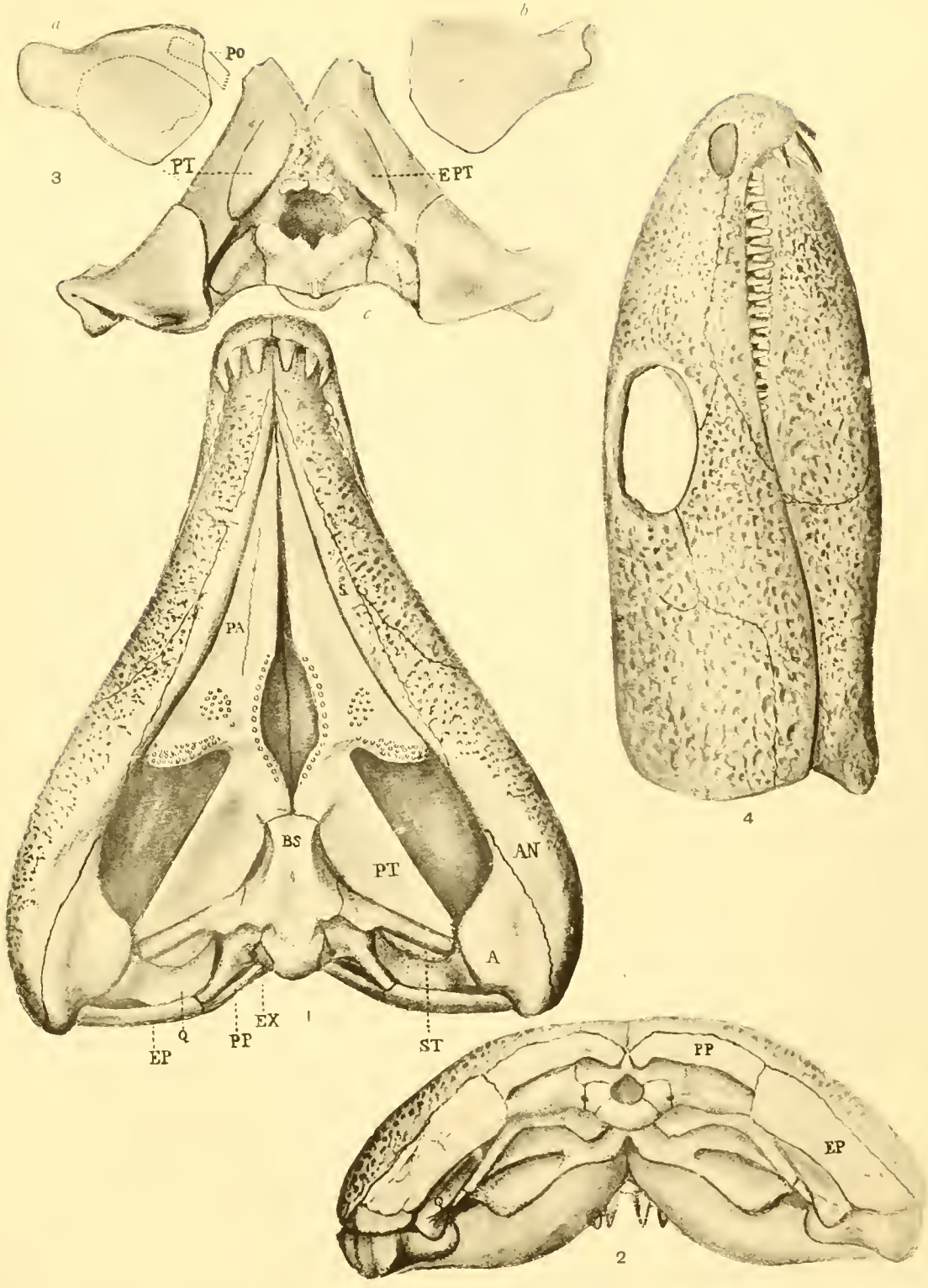
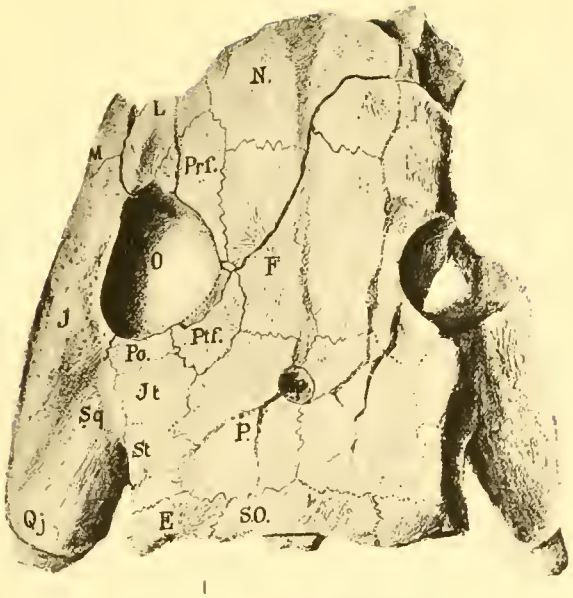
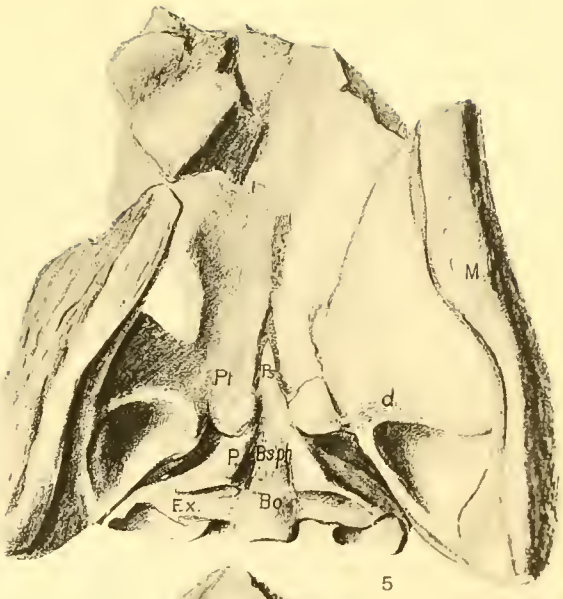
1. Side view of skull of *Captorhinus angusticeps*. × 1. No. 4457 Am. Mus.
2. Lower view of skull of *Captorhinus isolomus*. × 1. No. 4338 Am. Mus.
3. Top view of skull of *Captorhinus auguti*. × 1. No. 4334 Am. Mus.
4. Posterior view of humerus of *Desmospondylus anomalus*. × ⅔. No. 6541 Univ. of Chicago.
5. Anterior view of same.



1. Lower view of skull of *Labidosaurus hamatus*, from Williston. × 1. Restored from No. 641 Univ. of Chicago. *s*, splenial; *pa*, palatine; *an*, angular; *pt*, pterygoid; *bs*, basisphenoid; *a*, articular; *st*, stapes; *ep*, quadratojugal; *ex*, exoccipital; *pp*, paroccipital.
2. Posterior surface of same. *pp*, paroccipital; *ep*, quadratojugal; *q*, quadrate.
3. Occipital region of same. *pt*, pterygoid; *ept*, epipterygoid.
4. Lateral view of same. × 1.



1



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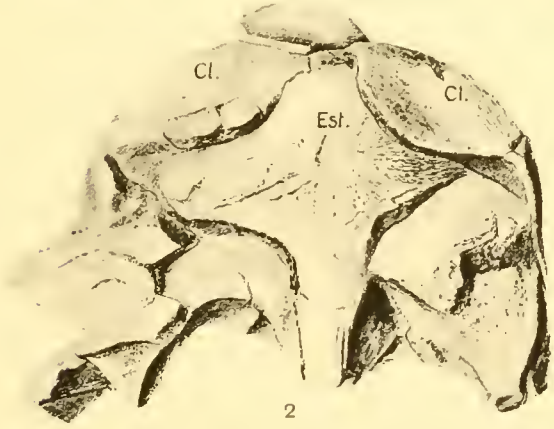

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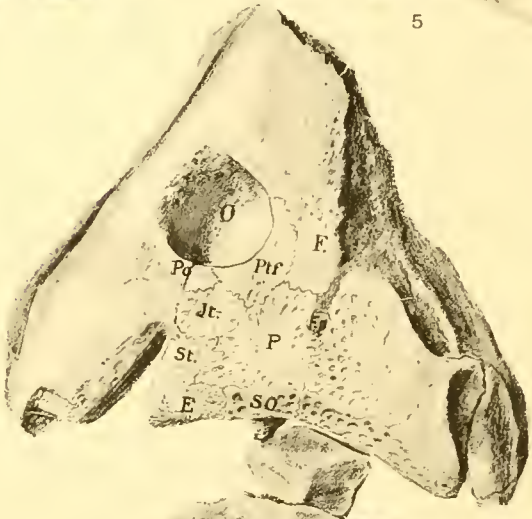
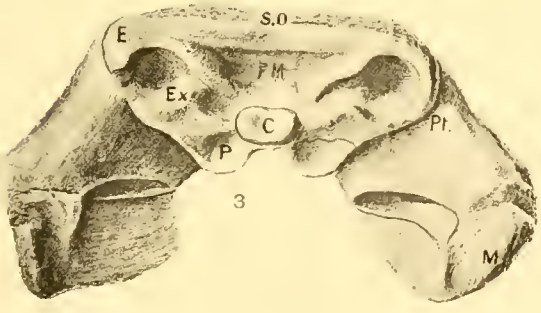
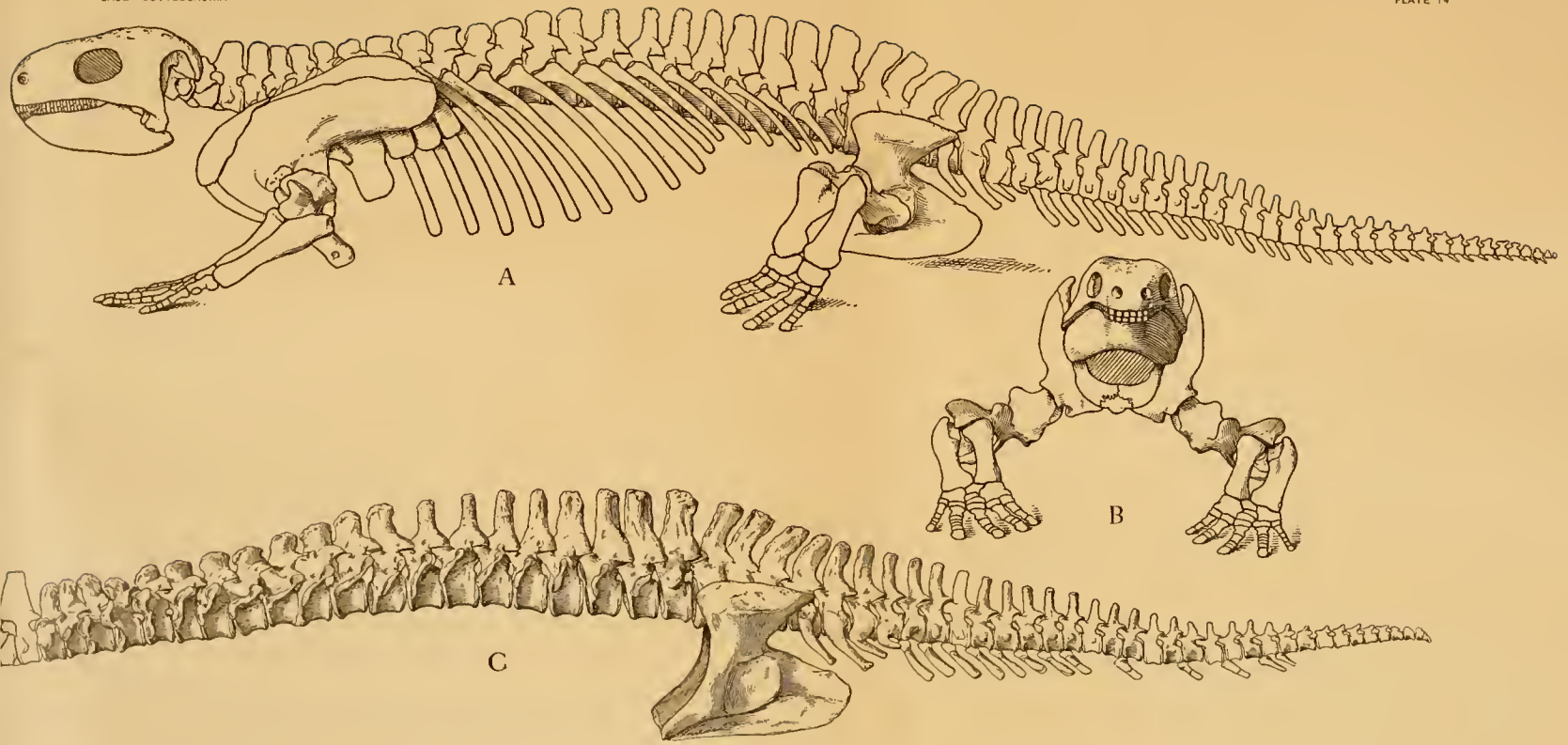




3

4

1. Top view of skull of specimen of *S. baylorensis*. × ⅔. From Broili. *n*, nasal; *l*, lachrymal; *prf*, prefrontal, *o*, orbit; *m*, maxillary; *ptf*, postfrontal; *po*, postorbital; *j*, jugal; *f*, frontal; *jt*, intertemporal; *sq*, prosquamosal; *st*, squamosal; *e*, epiotic; *p*, parietal; *so*, supraoccipital plates.
2. Clavicles and interclavicle of *Seymouria*. × ⅔. From Broili. *cl*, clavicle; *est*, interclavicle.
3. Posterior view of skull of *Seymouria*. × ⅔. From Broili. *e*, tabulare; *so*, supraoccipital plates; *ex*, exoccipital; *fm*, foramen magnum; *pt*, pterygoid; *c*, condyle; *p*, paroccipital; *m*, mandible.
4. Skull and anterior vertebræ of *Seymouria*. × ⅔. From Broili. Letters as in fig. 1.
5. Lower surface of skull of *Seymouria*. × ⅔. From Broili. *ps*, parasphenoid; *bps*, basisphenoid; *bo*, basioccipital; *c*, condyle; *pt*, pterygoid; *p*, paroccipital; *d*, remains of small teeth.



A. Restoration of the skeleton of *Diadectes phaseolinus*. $\times\frac{1}{6}$.
B. The same, anterior view.
C. Vertebral column of *Diadectes phaseolinus*. $\times\frac{1}{6}$. No. 4684 Am. Mus.

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